EAST AFRICA HIGH COMMISSION

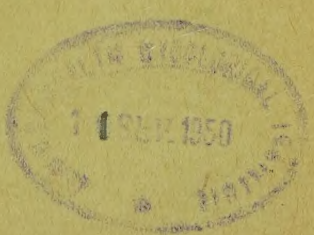
East African Agriculture and Forestry Research Organisation

(Incorporating the East African Agricultural Research Institute, Amani)

ANNUAL REPORT 1949

Obtainable from the Secretary, East African Agriculture and Forestry Research Organisation, P.O. Box 601, *Nairobi, and from Booksellers.*

Price 2/50



EAST AFRICA HIGH COMMISSION

East African Agriculture and Forestry Research Organisation

(Incorporating the East African Agricultural Research Institute, Amani)

ANNUAL REPORT 1949

Obtainable from the Secretary, East African Agriculture and Forestry Research Organisation, P.O. Box 601, *Nairobi, and from Booksellers.*

Price 2/50

Printed by
The East African Standard Ltd.
Nairobi, Kenya.

Staff List as at 31st December, 1949

(Including officers of the Native Fertiliser Scheme and the Clove Research Scheme, Zanzibar)

DIRECTOR

B. A. Keen, D.Sc., F.Inst.P., F.R.S.

DEPUTY DIRECTOR

H. H. Storey, C.M.G., M.A., Ph.D., F.R.S.

RESEARCH OFFICERS

H. F. Birch, Ph.D., F.C.S.
(Soil Chemist — returned from leave 4th September, 1949)

I. W. M. A. Black, Ph.D., A.I.C.T.A.
(Soil Chemist)

L. R. Doughty, B.Sc. (Agric.), N.D.A.
(in charge Fertiliser Research Scheme — proceeded on leave 13th August, 1949)

D. W. Duthie, M.A., Ph.D., F.R.I.C.
(Soil Chemist — returned from leave 12th April, 1949)

J. Glover, M.Sc.
(Plant Physiologist — proceeded on leave 18th October, 1949)

P. J. Greenway, F.L.S.
(Systematic Botanist)

R. F. W. Nichols
(Assistant Plant Pathologist)

F. J. Nutman, D.Sc., D.I.C.
(Plant Physiologist, seconded as Director, Clove Research Scheme)

P. Robinson, B.A., Dip. Stat.
(Statistician)

D. Rudd Jones, M.A., Ph.D.
(Mycologist — assumed duty 6th May, 1949)

Miss F. M. L. Sheffield, D.Sc.
(Seconded to Clove Research Scheme — assumed duty 27th December, 1949)

B. Verdcourt, B.Sc.
(*Assistant Taxonomic Botanist — assumed duty at Royal Botanic Gardens, Kew, 1st October, 1948 — arrived East Africa 26th November, 1949*)

SCIENTIFIC ASSISTANTS

Miss A. L. Alexander, B.Sc.
(*Junior Chemist*)

Miss D. M. Cooper, Dip. Agr.
(*Assumed duty Fertiliser Team, 17th January, 1949*)

Mrs. R. I. Robb, B.Sc.
(*Clove Research Scheme*)

Mrs. A. K. Ryland, B.Sc.
(*Assumed duty 4th March, 1949*)

Miss E. Smith, B.Sc.
(*Assumed duty Fertiliser Team, 17th January, 1949*)

SECRETARY

T. Matthews, T.D.
(*On vacation leave February/October, 1949*)

ASSISTANT SECRETARY

S. G. Walter
(*Assumed duty 1st January, 1949*)

STOREKEEPER

D. Smith
(*Assumed duty 1st April, 1949*)

PRIVATE SECRETARY TO DIRECTOR

Miss M. A. E. Vardy

FARM MANAGER

H. P. Ledger, N.D.D.
(*Assumed duty 1st November, 1949*)

ENGINEER

T. V. Greenwood

CLERK OF WORKS

L. C. Martin, M.B.E.
(*Seconded to East African Railways and Harbours.*
(*Engaged on Muguga contruction.*)

LIBRARIAN (RESEARCH)
Miss J. Ossent, M.A.

FIELD OFFICER
D. W. Gourlay, B.A. (Agric.)
(*Field Experimentalist — Fertiliser Team*)

FIELD ASSISTANTS
W. J. L. Arthur-Worsop
(*Fertiliser Team*)

T. Brodie
(*Fertiliser Team — assumed duty 21st August,* 1949)

T. Graham
(*Fertiliser Team*)

P. H. Hosegood
(*Fertiliser Team*)

W. B. May, F.R.H.S.
(*Seconded to Clove Research Scheme, 21st September,* 1948)

J. D. Roberts
(*Assistant Superintendent of Plantations*)

T. E .C. Robins
(*Clove Research Scheme*)

ASIAN CLERICAL STAFF
P. Amorgum
N. L. Mandaliya
L. C. Mathias

TEMPORARY CLERICAL ASSISTANTS
Mrs. D. M. Smith
(*Assumed duty 1st September,* 1949)

Mrs. M. Y. Robinson
(*Assumed duty 1st September,* 1949)

Mrs. M. Doughty
(*Departed on leave 13th August,* 1949)

Under Colonial Development and Welfare Schemes, administered by the Organisation:—

G. Salt, Sc.D.
(*Entomology*)

A. Walter, O.B.E.
(*Agricultural Meteorology*)

W. V. Harris, M.Sc.
(*Colonial Termite Research Scheme, assumed duty 21st September*, 1949)

Report by the Director

The First Annual Report of this Research Organisation gave an account of its origin and developments as far as the early months of 1949. These developments have proceeded throughout the year ; but the main factor limiting progress continues to be the physical establishment. The rate of advance towards a fully staffed and comprehensive research organisation depends primarily on the rate of building laboratories and dwelling houses.

At the close of the year the general position remained little altered from that at its opening, with Amani still the only centre for laboratory research. Nevertheless substantial progress has been made in the inevitable slow process of developing a new research station on an area of undeveloped land at Muguga. These new developments, however, had not gone to a point allowing any reduction in the effort and cost of maintaining the Amani station ; and so long as Amani continues to be occupied maintenance cannot be neglected except at the risk of the health and efficiency of the research staff.

For the greater part of the year Amani remained also the general administrative headquarters of the Organisation, with Mr. S. G. Walter, Assistant Secretary in charge, under the Deputy Director, after the departure on leave in February, 1949, of Mr. T. Matthews. Before the close of the year, however, it had been possible to begin a move of the administration to Nairobi, where it came more closely under the Director's control and was, moreover, much facilitated by proximity to the headquarters of the High Commission. The Nairobi office was augmented, first, by Dr. D. W. Duthie, who took charge of the technical planning of the new headquarters as well as editing of the *East African Agricultural Journal* ; and, secondly, by the Secretary, Mr. T. Matthews, with additional clerical staff. At the end of the year all establishment matters and accountancy for capital development had been transferred to Nairobi ; and it is planned to concentrate all central accountancy in new buildings at Muguga from about the middle of 1950.

It is expected that the second half of 1950 will see the beginning of the main moves of scientific divisions to new quarters in Kenya. No date can, however, be forecast for the completion of these moves and for the final withdrawal from Amani (except for a small permanent outpost) ; indeed, the demands on the Amani housing are likely to be maintained as newly appointed staff takes the place of those moved to Muguga.

Planning of Research

Following the general discussions upon research policy at the first meeting of the East African Advisory Council for Agriculture, Animal Industry and Forestry, held in 1949, three specialist conferences were called to plan and review research in special limited fields.

On the 13th and 14th July, a discussion was held on fertiliser experiments in East Africa, under the chairmanship of the Director, E.A.A.F.R.O., and attended by representatives from the four East African Departments of Agriculture, the Overseas Food Corporation,

the Empire Cotton Growing Corporation, the East African Industrial Research Board, African Explosives and Chemical Industries, Ltd., and with other members of the staff of E.A.A.F.R.O. Mons. A. Focan, I.N.E.A.C., Yangambi, Belgian Congo, also presented a review of fertiliser trials in the Belgian Congo and took part in the discussion.

The papers and discussion, which are summarised in the *East African Agricultural Journal*, Vol. 15, No. 2, October, 1949, p.61, covered most aspects of fertiliser trials in East Africa, and emphasis was laid on the irregularity of the responses to fertilisers in the trials under review. Statistical evidence indicated that, in East Africa, rainfall has more effect on response to fertilisers than soil type, since soil moisture is usually the limiting factor in East African agriculture. On the other hand, trials by the Empire Cotton Growing Corporation in Ukiriguru, Tanganyika, have given large responses to dressings of organic manures, with residual effects too great to be accounted for by the amount of organic matter added to the soil. The influence of nitrate accumulation in soil under fallow was also discussed in relation to responses from phosphate and nitrogen.

A meeting of the specialist committee on grassland research was held in Nairobi on the 7th and 8th December. A wide range of papers was read and discussed, since the subject was treated as a branch of plant and animal ecology rather than as a self-contained subject. While a great deal of work had been carried out in East Africa, it was evident that it required collation, not only in itself, but also in relation to the broader aspects of animal husbandry and plant ecology. The papers and discussion will be published in the April, 1950, number (Vol. 15, No. 4) of the *East African Agricultural Journal*, and a series of recommendations will be submitted to the next meeting of the Advisory Council.

A specialist committee met on the 29th November to discuss the utilisation of water by vegetation. No papers were tabled at the meeting, but members summarised the investigations which had been carried out on the subject. It was evident that an understanding of water utilisation by vegetation could be attained only by co-operation between several departments ; agriculture, forestry, meteorology, and hydrology, and it was noted that this collaboration is already in being and will be continued. Insufficient experimental evidence was available for broad conclusions, but difficulties in the technique of measuring soil moisture *in situ* are being overcome, and it is hoped that the work will be extended in the future. A noteworthy contribution to the meeting was made by Mr. A. Walter, formerly Director of the East African Meteorological Department, whose recent studies of solar radiation in relation to soil moisture (summarised elsewhere in this Report) are likely to be of the utmost value in assessing water utilisation by vegetation.

During the year senior officers of the Organisation attended four Conferences outside East Africa. The Director headed a Colonial delegation to the Commonwealth Conference on Plant and Animal Nutrition in relation to Soil and Climatic Factors held in Australia in August and September. The Deputy Director was a member of the East African delegation to the African Regional Scientific Conference in Johannesburg in October and November. Both these Conferences

had been called to follow up resolutions of the Royal Society and Official Commonwealth Conference of 1946. In November, Mr. L. R. Doughty travelled to Jos, Nigeria, to attend Conferences on Land Utilisation and on Indigenous Rural Economy.

By invitation of the Overseas Food Corporation, Dr. Keen and Dr. Storey became members of a Scientific Advisory Committee to the East African developments by the Corporation. This Committee met once under the chairmanship of the Overseas Food Corporation's regional General Manager, Professor J. Phillips.

The year has seen important visits by missions representing the Economic Co-operation Administration. First, Mr. Harry Stage visited Nairobi for discussions of entomological problems and particularly the agricultural use of insecticides, with a view to E.C.A. assistance in co-operative research between the Research Unit of the Colonial Insecticides Committee, the Uganda Station of the Empire Cotton Growing Corporation and this Organisation. Later a larger mission composed of Mr. W. V. Lambert, Dean of Nebraska Experiment Station and College ; Mr. M. A. McCall, Assistant Chief, Bureau of Plant Industry, U.S. Department of Agriculture Research Centre ; and Dr. Marlin G. Cline, Professor of Soil, Cornell University, in a wide tour of East Africa, visited both the Nairobi headquarters and the Amani Station of the Organisation. Their studies of East Africa's needs in agricultural research resulted in their recommending a number of projects in which American scientific workers could appropriately give assistance. The Organisation is likely to be closely concerned in many of these projects.

Dr. Storey served as a member of a commission appointed by the Secretary of State to advise on the control of the sudden-death disease of Cloves in Pemba Island.

Progress of Research

Although planning and construction have taken a prominent part in the year's activities, substantial progress has been made in research. In the following pages will be found reports by the heads of sections and by individual research workers. They embrace not only the research by the Organisation's staff, but also that by individuals or teams more or less closely related to the Organisation. These include the Fertiliser Experiments team at present financed in part under an independent C.D. & W. Research Scheme, but shortly to be absorbed into this Organisation ; the Clove Research Scheme in Zanzibar for which the Director of E.A.A.F.R.O. has responsibility for scientific supervision ; and smaller schemes for meteorological studies and for survey of arthropod fauna of soils. The Organisation has assumed responsibility for administering a C.D. & W. Research Scheme for Colonial termite investigations, so long as the team may be working in East Africa.

It is satisfactory to be able to report the establishment of a Statistical Research Section of the Organisation, thus meeting a need to which attention has been drawn in successive Conferences during the past twenty years in East Africa. The services of Mr. P. Robinson and his at present small staff of computers have been in demand, pre-eminently by the Fertiliser Experiments Scheme and the related

Highland Fertiliser Scheme of the Kenya Government, but also by other research sections of the Organisation and by Experiment Stations and Departments of Agriculture in East Africa. The main function of this Section is research into and advice upon the design and analysis of agricultural and other biological experiments, with a secondary function, so far as staff permits, of the analytical computation of results for those workers requiring it.

Co-operative work on the large question of soil fertility has continued on the lines described in the last report. The Fertiliser team, under Mr. L. R. Doughty and Mr. D. W. Gourlay, during the former's absence on overseas leave, succeeded with only a small augmentation of staff in increasing its total number of field experiments and in extending its activities into the Coastal area. An unfortunate season of widespread drought was responsible for an exceptionally large number of failures. A general statement of the results to date and certain tentative conclusions will be found in Mr. Doughty's report ; but it is evident that firm conclusions on the nutrient status of soils in the areas of East Africa studied can only be reached after several further years' trials.

In the Section of Soil Chemistry, augmentations of the junior staff, together with the establishment of the spectrographic technique as a working tool, permitted Dr. Black to complete by the end of the year analyses of the soil samples from all the field fertiliser experiments laid down in 1948 and 1949.

Time has, however, not yet permitted the lengthy statistical studies necessary to decide whether any relation can be found between the chemistry of the soils and the response of crops on them to fertilisers. Dr. Birch, though absent on overseas leave for most of the year, reports on methods of fractionating soil phosphates and finds some indication of a relation between the adsorbed phosphate in a soil and response to phosphate fertilisation. In the Plant Physiology Section, Mr. Glover continued his studies on the uptake of nitrogen and phosphate by maize grown in sand culture, until he also departed on overseas leave.

On the biological side of the Organisation's research the main expansion has been in the Plant Pathology Section. With the arrival of Dr. D. Rudd Jones it has become possible to start work in the mycological and bacterial fields ; and at present he is concentrating on problems of forest mycology. The Amani laboratory has been mainly occupied in studies of groundnut virus diseases and their transmission by aphis-vectors ; and it has also been possible to breed pure physiological races of *Cicadulina mbila*, the vector of maize streak disease, as material for future further studies on the nature of the transmission process. Mr. Nichols has continued field experimental trials of the great number of cassava clones bred for resistance to the two virus diseases to which the crop in East Africa is subject.

Mr. Greenway has continued to give services from the Herbarium to many correspondents in East Africa and overseas. He accompanied Mr. A. C. Hoyle, of the Imperial Forestry Institute, Oxford, on an extended tour of Tanganyika, undertaken especially for the study of the genus *Brachystegia*. Mr. Verdcourt worked during the year at the

Herbarium of the Royal Botanic Gardens, Kew, mainly on identifying or verifying duplicate specimens sent there from Amani.

The Clove Research Scheme has maintained its search for the cause of the "Sudden-death" disease of clove trees. Although no evidence has been obtained in conflict with the hypothesis that the disease is caused by a virus, rigid experimental proof still remains lacking. It is well-known to specialist workers that studies of virus diseases of trees are technically difficult and slow ; and the clove tree has proved to be unusually unresponsive to handling by the customary experimental techniques. The failure so far of a large range of experiments to provide conclusive results is disappointing but not unexpected.

Dr. G. Salt reports on his studies of the arthropod fauna of East African soils, carried out with the help of a grant under the Colonial Development and Welfare Acts during the period July, 1948, to April, 1949. In the soils studied the arthropod population was markedly lower than that normally found in British soils ; and the dominance of ants within these populations is a point of considerable interest.

In his report, Mr. Walter records progress in his statistical examination of meteorological data, aiming ultimately at devising means for delimiting agricultural zones on a basis of meteorological observations that can be easily and cheaply obtained. Important progress has been made in relating the incoming solar radiation with air-temperature observations. An analysis of rainfall data is in progress.

Construction and Maintenance

The constructional work in which most progress can be shown is the new Herbarium. In accordance with the general policy of concentrating East African taxonomic research around the Coryndon Museum, Nairobi, the existing Amani and Coryndon plant collections are to be merged in a single East African Herbarium. The new building to house it, constructed at the cost of His Majesty's Government under C.D. & W. Scheme R.334, is nearing completion on a site adjacent to the Museum. It is planned to move the Amani collection about the middle of 1950, after allowing ample time for drying out the building at Nairobi.

At Muguga work on actual construction was started in March, 1949, when Mr. L. C. Martin, M.B.E., Clerk of Works, took up residence in a temporary house on the site. Prior to this, a contour survey of the area had been carried out in 1948 by C. E. Surveys, Ltd., and some 400 acres of wattle had been cleared by contractors under the Kenya Forest Department. Two boreholes had also been sunk, and when tested later in the year they gave over 4,000 gallons per hour on a 48-hour test. A third borehole was unsuccessful, and when the results of the tests on the two others were known it was not considered necessary to have more than two at present.

Mr. Martin built a 100,000-gallon water tank, and one European house in local stone with only African labour, and these were the only buildings completed during the year. Fourteen European houses, three Asian houses, and twenty African houses were put out to contract in November, and construction of these were well under way at the end of the year. Detailed working plans were prepared by the Architect for the first block of laboratories, comprising eight main and eight

ancillary rooms, and also for the Library, and it is anticipated that construction of these will begin at the end of February, 1950. The internal fittings of the laboratories were also planned in detail, and the necessary equipment was ordered from the United Kingdom. An order was also placed for a Mansfield oil-gas plant with a 4,000 cubic feet gasholder ; this plant is capable of being doubled in capacity if required in later years.

Preliminary plans were also drawn up for the second block of laboratories and for the administration offices, and it is hoped that construction of these will begin about the middle of 1950. Plans for a hostel and for the farm buildings and animal husbandry unit are still in the preliminary stages.

The main road of access to the laboratories, over two miles in length, was surveyed and put out to contract. Work on this began in November, and the road should be finished as far as the laboratories by the end of May.

Electric power has been installed at the borehole which is now being used, an electric pump has been substituted for the temporary diesel pump, and a wayleave for water, electricity and telephone services has been cleared and prepared for these installations. Most of the main water piping is now in place.

Formal application was made to the Kenya Government for the excision of approximately 1,600 acres of the Muguga Forest Reserve for the new headquarters and farm, and provisional agreement to this was obtained ; but, towards the end of the year the plans for the new headquarters of the East African Veterinary Research Organisation were revised, and final excision of the area was postponed until it could be related to the new requirements of the veterinary research organisation.

Meanwhile it has been necessary to maintain the Amani station in full working order. Reference was made in the last Report to the numerous tasks that fall on the administrative staff in maintaining what amounts to a small isolated township, without outside help. During 1949 we were forced to undertake several large items of maintenance that had been neglected during past years in the expectation of an early move. In particular corrosion of pipe lines had reduced domestic and laboratory water supplies to a dangerous point ; and the heavy task of taking up, cleaning and replacing almost the whole of the distribution system was in progress at the end of the year. The Amani housing has generally been occupied to its full capacity ; to accommodate the increasing Asian staff, an old German house used recently as a store was rehabitated and enlarged ; and temporary additions to African housing have been built.

A major emergency occurred when Amani was cut off from access by wheeled traffic through the collapse of the bridge over the Sigi River under a heavy steam engine being moved to a sawmill in the hills. The station Engineer, Mr. Greenwood, with help from the Tanganyika Public Works Department, reconstructed the bridge in three weeks.

Apart from general maintenance work, the Amani workshops have been occupied on the overhaul of eleven new trucks—which arrived damaged by sea water on the voyage out—and the construction of new

bodies for them ; and also on the construction of cabinets for the new Herbarium. On the completion of this work early in 1950 some of the staff and plant will be transferred to new workshops at Muguga.

Work on the maintenance of the Amani plantations has been reduced to the minimum possible ; but nevertheless it has been necessary to retain a considerable labour force to carry on the numerous activities of the Superintendent of Plantations. Costs, however, are largely balanced by income from sales of various agricultural products, including four tons of Cinchona bark, and 1,500 lb. of tea seed, besides many miscellaneous plants and seeds for which a demand from the public continues. The quarantine houses have been partly occupied by imported sugar canes and other plants. The Kizugu sub-station has been re-opened, after three years' grass fallow, for the Pathology Section's Cassava and Groundnut trials.

During this last year of our custody of the Kwamkoro Estate we were unfortunate to lose by fire the old drying shed that has served the estate since German days. Crops of Cinchona, Aleurites and Derris were reaped, but a part was lost in the fire. From 1950 management of the estate reverts to the Government of Tanganyika, except for small areas reserved for maintaining the Cassava collection. The cattle herd passes to the ownership of E.A.A.F.R.O.

Library

Miss J. Ossent, *Librarian (Research)*
Mrs. Black, *Temporary Assistant*

The Amani Library started with the collection of scientific books of the Biologisch-Landwirtschaftliches Institut, which was transferred to the East African Agricultural Research Station in 1927. It evolved during the succeeding years in the fields of agricultural and biological sciences and grew rapidly, thanks mainly to a permanent endowment of £10,000 from the Carnegie Corporation as well as donations from scientific institutions in the U.S.A., India and the Dutch East Indies. At present it is the largest library of its kind in East Africa. It holds 13,000 books, including 8,000 bound volumes of periodicals, and receives 385 current journals printed in 13 languages. The fields covered are, besides agronomy and technology, soil science, botany, forestry, horticulture, plant pathology, zoology, entomology, and the biological, chemical and physical sciences.

The main activities of the year consisted in making a preliminary survey of the book and periodical collection, in clearing files, recording and filing publications and dealing with all arrears caused by lack of adequate staff in two preceding years. African assistants were trained to use routine library techniques.

A thorough inventory of the periodicals revealed 785 entries, comprising, besides 400 non-current sets, 125 journals received by paid subscription, 245 in exchange for Amani publications and/or the *East African Agricultural Journal*, and 15 received as gifts. The sets and current publications were identified and filed under their respective classes, shelves were rearranged, and scattered issues were collected for binding. Both the compiling of the periodical catalogue and the

procuring of back issues are still in progress. Official publications from East African territories and all separates from Agricultural Experiment Stations were collected and classified.

The Library Exchange mailing list, covering 62 countries, was brought up to date and corrected upon written enquiry. Where the exchange had lapsed during the war, arrears of publications kept in stock were dispatched. This project was mainly carried out by Mrs. Black, who has been assisting in the library since the middle of February. Whereas the mailing list numbered only 350 entries at the beginning of 1949, it had reached 580 by December. This revision, which was carried out in collaboration with Dr. Duthie and the Government Printer in Nairobi, also furnished an accurate list of journals received in exchange for the *East African Agircultural Journal.*

The new index catalogue for text-books was started in June. By December the Plant Pathology reading room, Herbarium reading room and part of the Main Library had been catalogued and 1,300 entries recorded. The old classification system was modified and adapted to our present needs and a subject index catalogue (i.e. dictionary catalogue) was evolved. Further improvements were the fitting of each book-cover with class-number label and an inside-pocket bearing a record card for recording date and name of borrower. A number of rare books on botany and mycology either received new bindings or were carefully repaired.

The Library Monthly Bulletin, announcing current accessions, was started in March, and the first Interim List of Current Periodicals appeared in July.

Additions to the Library during 1949 were 148 books, 26 periodical titles (12 received by subscription and 14 by exchange), 73 annual reports and 217 pamphlets.

Publications sent out under our Inter-Library Loan agreement totalled 120. All were returned in good condition.

The book-binding staff was reorganised, necessary equipment and material was provided to make continuous book-binding service possible. A total of 450 books were bound or repaired and about 70 pamphlet boxes were made and labelled.

East African Agricultural Journal

D. W. Duthie, *Editor*

In former years, editorship of this Journal was vested in the Director of the E.A. Agricultural Research Institute, and this arrangement was maintained during the first year of the East African Agriculture and Forestry Research Organisation. As a result of a recommendation passed in January, 1949, by the East African Advisory Council for Agriculture, Animal Industry and Forestry, the Editorial Board was extended to include Directors of Agriculture, Directors of Veterinary Services, and Conservators of Forests of Kenya, Tanganyika and Uganda, in addition to the Director of Agriculture, Zanzibar; and a small Executive Committee was set up, consisting of the Director, East African Agriculture and Forestry Research Organisation, the Director, East African Veterinary Research Organisation, and the Editor. Thus a separate post of Editor was created, and in April, 1949, the editorial office was moved from Amani to Nairobi, and Dr. D. W. Duthie took over the editorship. It was decided that, for the time being, no Assistant Editors would be required, and thanks are due to Mr. P. J. Greenway, of E.A.A.F.R.O., and Mrs. M. E. Luckham, Librarian in the Kenya Department of Agriculture, for their services as Assistant Editors during the past few years.

During the immediate postwar years, 1945-1949, shortage of technical staff in the territorial departments and research stations, coupled with the extra work involved in postwar developments, caused a scarcity of material for publication, but during the latter half of 1949 articles were in better supply. and present prospects indicate that there should be no difficulty in obtaining sufficient material in future. There is, however, a lack of articles and notes of practical value to East African farmers, although articles on diseases of animals and plants are increasing in number. One of the chief functions of this Journal is to maintain records of investigations in East Africa, and for that reason it is sometimes advisable to publish severely technical articles which may not convey much to the farmer but which will be of assistance to technical officers and research workers. The time may come when it is feasible to publish a strictly practical farm journal in East Africa, but until then this Journal provides the only means of recording practical suggestions and investigational results in agriculture, forestry, animal industry, veterinary science and fishery research.

At the end of 1949 the circulation was : subscribers and sales in bookshops, 1,380 copies ; free distribution, 254. Copies are sent to libraries and technical laboratories in some fifty countries, and it is evident that this Journal is fulfilling one of its functions, namely that of keeping scientists in other parts of the world in touch with work carried out in East Africa.

Section of Plant Pathology

STAFF

H. H. Storey	*Deputy Director*
R. F. W. Nichols	*Plant Pathologist*
D. Rudd Jones	*Plant Pathologist*
Mrs. A. K. Ryland	*Scientific Assistant*

Research on virus diseases of plants has continued at Amani on the general lines set out in the 1948 Report. Mr. Nichols has been fully occupied in the laborious task of testing the many clones of Cassava hybrids raised in previous years and in maintaining healthy stocks, for which it has been necessary to open a new area on Kwamkoro Estate. Groundnut rosette studies have been the main preoccupation of Mrs. Ryland since her appointment in March, 1949, together with the breeding of the insect-vector of Maize Streak Disease.

Dr. Rudd Jones, who arrived in May, 1949, undertook a short preliminary survey of certain suspected fungal and bacterial diseases of Clove plants in Zanzibar ; and in July, 1949, established his headquarters in a field laboratory near Nyeri, Kenya, for studies of forest pathology in general and of the canker of *Cupressus* spp. in particular, in co-operation with the Kenya Forestry Department.

By an arrangement with the Director of Agriculture, Kenya, Dr. R. M. Nattrass, Plant Pathologist to the Department, spent the month of November, 1949, in the Union of South Africa, visiting main centres of pathological research. His chief commission was to become fully acquainted with recent advances in research on virus diseases of fruit trees. Since the fruit industry in East Africa has been built up mainly with plants imported from nurserymen in the Union, there is every reason to suppose that the virus diseases, mostly unrecognised until recently, have come into this country ; and in fact Dr. Nattrass has already found some in material from Kenya. His report will be of great value to East Africa, not only by providing up-to-date information on these obscure diseases but also for the guidance that it gives to future import policy. The assistance that Dr. Nattrass received from officers of the Union Department of Agriculture and others is greatly appreciated.

VIRUS DISEASES OF CASSAVA—R. F. W. Nichols

Previous annual reports have indicated the lines along which the long-term cassava breeding project has been developed. Its purpose is to minimise, if not entirely to overcome, the ill-effects on East African cassava production caused by the two virus diseases, mosaic and brown streak. The fundamental basis on which improvement is sought is by inter-specific hybridisation of woody-rooted wild species of *Manihot* with the tuberous-rooted cultivated cassavas, and by subsequent backcrossing to the latter through as many generations as may be necessary to restore fully tuberous roots of the desired agronomic quality while retaining the disease resistance of the wild species.

Much has already been done to achieve these objectives. Year-to-year progress is relatively slow, since a minimum of three years is required to raise a single generation from seed, multiply the seedlings

by vegetative propagation and then to carry out field trials for disease resistance and cropping qualities. For this reason I have little to add to my last report beyond recording that satisfactory progress has been maintained. The number of clones being handled is increasing from year to year and it is inevitable that the amount of routine work involved is also increasing. A considerable labour force is now employed solely on this work.

The field testing of clones is carried out in two stages, as has been previously described. A preliminary resistance trial carrying 1,620 clones from the 1947 breeding season which was started in October, 1948, was harvested in July, 1949. On the basis of this trial some clones show great promise both in disease-resistance and in quality and quantity of roots produced. Three hundred and fifty of these clones were retained for further testing in fully replicated trials, the results of which will be available by the middle of 1950. Those that continue to show high disease-resistance will be multiplied and made available for distribution.

An outstanding feature of the above trail was the very high resistance to brown streak shown by a group of F_1 *M. melanobasis* hybrids. It appears probable that one back-cross only will suffice to restore fully tuberous roots in this material. Unfortunately this species contracts mosaic readily but it may prove possible to introduce factors for mosaic resistance by the method of triple hybridisation. The roots of *M. melanobasis* have a high protein content which is a further reason for persevering with hybrids of this species.

The 1948-49 replicated trial was also terminated in July. Eight of the sixty clones in this trial came through without a single plant contracting mosaic. All but two of these eight clones showed high brown streak resistance but only one gave a satisfactory yield of roots. This trial was harvested after a growth period of only eight months ; except for clones which mature very quickly this is too short a growing period to determine relative yields with any degree of accuracy. For this reason it would be advantageous to continue these field trials for at least a year or possibly 15 months, but this is seldom practicable because the land has to be used for the next season's trials.

During the year approximately 2,600 hybrid seedling clones were raised from the 1948 seed crop obtained by controlled pollination. Cuttings from 1,700 of these were planted out in preliminary disease resistance trials at the Kizugu sub-station in December. Simultaneously cuttings from these clones were planted in the propagation plots on Kwamkoro Estate. The balance was not sufficiently advanced to allow of cuttings being taken and they will be dealt with during the coming year.

The current replicated trials carrying a total of 300 clones were planted in August at the Sisal Experiment Station, Ngomeni. In the early stages of growth the plants were only kept alive by hand watering owing to failure of the October-November rains. The water was transported by lorry from a stream four miles away. Severe drought has continued to date and has resulted in many deaths. More are to be expected unless the situation is saved by the unlikely event of the long rains breaking much earlier than usual. Nevertheless, these experiments will not be an entire failure because the monthly record-

ings already give some indication of the relative disease resistance of different clones.

Mention has been made in previous reports of a particularly high-yielding ceara-cassava hybrid, No. 4332/2. This clone is highly susceptible to moisaic but even when grown from diseased cuttings individual plants have yielded as much as 75 lb. of fresh root after 18 months' growth. It therefore seemed worth while to test the yield of this clone against a standard high-yielding cassava variety. Accordingly a yield trial was planted up at Kizugu at the end of September. Hybrid No. 4332/2 is being tested against the cassava variety "Msitu". Both healthy and mosaic infected cuttings were used and they were planted to a modern experimental design. The trial will be harvested at 6, 12, 18 and 24-month intervals. The information derived from this experiment will decide whether it is worth while recommending extensive cultivation of this mosaic-susceptible hybrid pending the production of high-yielding disease-resistant types.

Until recently the cultivation of cassava in East Africa has been solely a peasant crop ; but some interest is now being shown in its production on a plantation scale. During the year cuttings of thirty clones were supplied for trial to a private concern which has started operations on the coast of Kenya. The object in this instance is production for export to Britain.

Publications

"The Brown Streak Disease of Cassava". *East African Agric. Journal*, vol. 15, 154-160.

VIRUS DISEASES OF GROUNDNUTS—H. H. Storey ; A. K. Ryland

By the agreed division of groundnut virus research between the Overseas Food Corporation and E.A.A.F.R.O., this Organisation is responsible for study of the more basic problems and particularly those concerned with insect transmission of the virus. Co-ordination has been maintained by visits to Amani of officers of the O.F.C. Scientific Division, and by two tours in the O.F.C. groundnut areas carried out by Dr. Storey ; and, at a high level, through Dr. Storey's membership of the O.F.C. Scientific Advisory Committee.

Experimental work has proceeded throughout the year at Amani, generally to the full capacity of the available greenhouses. The development of techniques has occupied a part of the time : techniques for the growing of groundnuts in the greenhouses, where abnormalities due to unbalanced nutrition have given trouble ; for grafting and mechanical transmission of the virus ; for the breeding of *Aphis craccivora* (Koch) (previously *A. laburni* [Kalt]) ; and for transmission experiments with this vector. For the first of these, a satisfactory potting compost has been found empirically, by adaptations of the John Innes system (Lawrence & Newell, *Seed and Potting Composts*, 1939). Other techniques developed will be mentioned in the following paragraphs.

The groundnut plant is easily grafted ; and the single-leaf method of Nattrass (1944, *Ann. Appl. Biol.*, 31, 310) has proved economical and reliable as a routine method for transmitting the viruses we are studying. By the use of grafting we have established in a single variety of

groundnut (" Natal Common ") in the greenhouses a number of types of virus diseases found in the field and have thus been enabled to study their behaviour under uniform conditions. This work is continuing and at this stage we have differentiated the viruses into two groups ; first, the " rosette " group, all of which produce the chlorosis and shortening of the axis typical of this disease, but vary individually in their quantitative effect ; and second, a group producing only a mild and often evanescent mottle on the leaves, with little general stunting of the plant. This differentiation rests at present on symptoms only ; but, whereas *A. craccivora* transmits the rosette group, it has failed hitherto in all experiments with the mottle group. It should be mentioned that forms of rosette disease have been described from field plants by others, e.g., Hansford and Hayes in *Agriculture in Uganda,*

Groundnut viruses have not, so far as we know, previously been transmitted by mechanical inoculation of juice. Our early experiments were uniformly unsuccessful; but by combining the use of celite (or carborundum), as an inoculation-aid in the juice, and prior etiolation of the plants to be inoculated (Kassanis, B. 1949, *Ann. Appl. Biol., 36,* 270), we have lately transmitted systemically the mottle group of viruses to a high proportion of the plants inoculated, and the typical rosette virus also to a low proportion. Work is proceeding upon the interaction of viruses of the two groups when inoculated into a single plant by the several available methods.

The major item on our programme is to study the behaviour of *Aphis craccivora* as a vector of the viruses. The breeding of the needed large numbers of aphides, both winged and wingless, has proved difficult, and we still lack a really reliable technique. This species is especially susceptible to high humidity and a fungus disease causes heavy losses when colonies are confined on plants in cages. Since we are trying to work with isolated aphis-strains, a system that will maintain the aphides in health and at the same time is economical of space is needed. The best results at present are obtained by enlarging the cages or even devoting a whole greenhouse-compartment to breeding aphides on uncovered plants.

For economy of space and convenience in manipulation we have used the following method for transmission experiments, developed from that employed by Posnette for cacao viruses (1947, *Nature, 159,* 500). Groundnut seeds, after a short germination period, have one cotyledon and the radicle removed, and are exposed to light for two days for the plumule to develop and green. These seeds are then exposed to aphides in watch glasses on the laboratory bench. At the conclusion of the test period the aphides are killed with an insecticide and the seeds planted in boxes in the greenhouse. Despite the mutilation they have undergone, the seeds grow, if somewhat slowly at first, into small but otherwise normal plants ; and rosette disease, if the virus has been successfully transmitted, can be diagnosed in about 12 to 20 days from the start of the test feed. A number of modifications in treatment of the seeds have been tested in replicated trials, but without significant differences in resulting infections. The method therefore appears to provide a satisfactory test of the ability of the particular aphides used to transmit virus under the conditions ruling.

An adaptation of the foregoing procedure has enabled us to send the rosette virus to Rothamsted Experiment Station, where Mr. F. C.

Bawden proposes to carry out certain studies on the virus. Half seeds, after exposure to infective aphides, were packed in damp sawdust and sent by air to England ; they survived the journey and the resulting plants were diseased.

A considerable number of replicated experiments have been carried out to determine how a range of treatment affects transmission by the aphis. Throughout the work there has been great inconsistency between the results from supposedly identical repetitions of the same experiment ; and in consequence we are not yet in a position to state many firm conclusions. Indications at present are that aphislines of differing origin have different abilities to transmit—we are seeking the help of a systematist to decide whether more than one species is concerned— ; that single adult aphides, both winged and wingless, can infect a plant ; and that the transmission process conforms to " persistent " type (Watson and Roberts, p. 939, *Proc. Roy. Soc.* B *127*, 543). It seems clear however that some factor, of which as yet we have no clue, is exerting a major influence on the success or failure of transmission.

That losses from rosette disease can be minimised by planting groundnuts at high density in the field is now generally recognised. Although experiments during 1930 in the Gambia had demonstrated a relation between spacing and rosette infection (*Ann. Rept., Dept. of Agric., Gambia* 1930-31), this effect appears to have been first recorded in East Africa in 1931, as a result of observation in the field in Uganda. Here the relative freedom from rosette of closely-planted African groundnut plots stood in marked contrast to the heavy rosette infection of adjacent widely-spaced plots (H.H. Storey, *Unpublished Report*, November, 1931). Spacing trails by the Uganda Department of Agriculture in 1931 and later years proved conclusively that by close spacing the percentage of rosetted plants at harvest could be markedly reduced. (*Ann. Repts., Dept of Agric., Uganda,* Part II). Confirmatory experiments have been reported elsewhere (e.g. Soyer, D. 1939, *I.N.E.A.C., Ser Scient., 21*), and close-spacing is now commonly advised where rosette disease is liable to occur.

For two reasons a need was evident for further studies in East Africa of this important practical control measure. In the first place, the operations of the Overseas Food Corporation called for an assessment of its efficacy in their several development areas. This work falls into the agreed research field of the Scientific Division of the Corporation, which may be expected to report the results of its trials in due course. A second need, and one falling within the E.A.A.F.R.O. field of research, was to determine if possible the underlying reason for the close-spacing effect. In studies to this end we have been fortunate to secure the interest and co-operation of Mr. J. D. Jameson and Mr. D. G. Thomas of the Uganda Department of Agriculture. With the agreement of the Director of that Department, these officers carried out during May to July, 1949, at the Serere Experiment Station what is probably the most exact field experiment that has been done to test the spacing-effect. The results of this experiment will be reported in detail by the Uganda Department of Agriculture; but it may be noted here that the experiment fully confirmed previous conclusions on the practical efficacy of close-spacing in reducing losses from rosette.

In recent years the question has been asked whether the value of close spacing lies, not in reducing the number of infections per unit

area of land, but rather in providing a larger plant population over which these infections are spread. Van der Plank (1944, *Farming in South Africa, 19* 391) has reported an example of the latter effect with the Kromnek disease of tobacco: an increase in the number of plants per acre produced a corresponding reduction in the percentage of plants diseased. The custom of reporting the results of groundnut experiments as "percentage of rosetted plants" has tended to conceal this posible explanation; and indeed when the reported results of many spacing trials are reduced from *percentage of rosetted plants* to *number of rosetted plants per unit area,* the advantage of close spacing becomes less striking or even disappears. The answer to the question whether close-spacing has any real effect in reducing infections per unit area has relatively little direct bearing on the practical use of this method of control; but it has an important theoretical bearing on the manner in which the virus is disseminated in the field.

Mr. P. Robinson, Statistician to this Organisation, has collaborated in the statistical analysis of the figures from the 1949 Serere experiment and of those from a number of earlier Uganda experiments kindly provided by Mr. Jameson. The conclusion may be briefly stated that the narrowest spacings do have a real effect in reducing the number of infections per unit area. The explanation will no doubt be forthcoming when the behaviour of the insect vector is more fully understood. Experiments along these lines will be continued in 1950.

The most effective advance that could be made in the control of rosette disease would be to breed types of groundnuts resistant to the virus. This has been recognised from an early stage both by the Overseas Food Corporation and ourselves. No known variety of this species, however, has given consistent evidence of high resistance, despite occasional reports from different countries in Africa of apparent resistance in one variety or another. It will almost certainly be necessary to seek genes for resistance from outside the species *A. hypogaea.* This point has been emphasised by Darlington, who has drawn attention to several known diploid wild species in South America (1948, *Nature, 162,* 621).

The breeding of interspecific hybrids of *Arachis* spp. is a task beyond the resources of the Plant Pathology Section and will require the attention of a specialist geneticist. We have agreed, however, to be responsible for the initial introduction and maintenance of breeding material, and for testing its resistance to the rosette virus. Unfortunately relatively little progress has been possible during the year. The Overseas Food Corporation obtained from their South American correspondents a number of samples of seed of wild *Arachis* spp. but all were dead when received at Amani. From the Senior Plant Introduction Officer, C.S.I.R., Australia, we have recently received directly plants of two types of *Arachis Diogoi Hoehne* and these are now established at Amani. Vegetative material of other species from South America has been established at the Royal Botanic Gardens, Kew, and we expect shortly to receive cuttings of these from the Curator.

The correspondents mentioned above have supplied seed also of a number of groundnut varieties. These have been grown once at Amani and 36 varieties have been passed to the O.F.C., Kongwa, for

trials in the field. They include several strains of the "Nambiquarae" type, regarded by some authorities as a species distinct from *A. hypogaea.*

VIRUS DISEASE OF MAIZE (Zea mays L.)—H. H. Storey ; A. K. Ryland

An important item in the research at Amani prior to the recent war was the study of the manner in which the leafhopper, *Cicadulina mbila* (Naude), transmits the virus of Maize Streak Disease. Work in the early thirties on the breeding of races of this insect, able and unable respectively to transmit the virus, had been the starting point for experimental studies of the transmission-process. During the war the pure races of *Cicadulina* were lost ; and in order to permit a continuation of these studies should opportunity arise, it seemed desirable to re-establish them.

Employing the methods already described (H. H. Storey, 1932, *Proc. Roy. Soc. B., 112,* 45) we have bred without difficulty pure "active" and "inactive" races of *Cicadulina mbila* (i.e., able and unable to transmit the virus). In the course of this work we confirmed the previous hypothesis that activity is due to a dominant factor linked with sex. The majority of the families bred showed the ratios expected from this hypothesis ; a few, however, did not. In an earlier Amani report (*E.A. Agric. Res. Sta., Ninth Ann. Rept.,* 1936-37, *17*) it was mentioned that such anomalous families had been encountered, and a tentative genetical hypothesis was advanced to explain them. A large mass of data from breeding experiments was accumulated in those and following years, but the war prevented us from preparing an account for publication. With the help of Mr. Robinson we are re-examining the old and also the new data.

Work on the breeding of Maize for resistance to Streak Disease (*E.A. Agric. Res. Stn., Thirteenth Ann. Rept.,* 1940, *8*) had to be discontinued in 1940. The seed from controlled crosses in that year has been carefully stored and some at least remains still alive. The material exists therefore for a continuation of the work when opportunity allows ; but it is essentially work calling for the co-operation between a geneticist and plant pathologist, and we are unlikely to be able to make much progress without the help of the former. Selection in the earlier breeding work was made on the results of controlled insect-infection tests ; and with the breeding of pure active races of *Cicadulina mbila* we are now in a position to carry out the necessary tests.

DISEASES OF CLOVES IN ZANZIBAR—D. Rudd Jones

A necrosis of the pith of clove seedlings

During the inspection of clove seedlings in Government Nurseries, W. B. May, Horticulturist, Clove Research Scheme, observed that a number had small zones of necrotic pith, particularly localised at the nodes. Dr. Sheffield (1949) in a histological examination of this phenomenon, found evidence suggesting that bacteria were associated with the necrotic tissue. The writer recorded the percentage of seedlings with necrosis in six nurseries and found that it varied from 4 to 40 per cent. in seedlings six months old, and from 24 to 68 per cent. in seedlings eighteen months old. The limited number of samples

taken, suggested that the distribution of necrosed seedlings in a nursery was not random. Five hundred naturally regenerated seedlings, examined in commercial clove shambas, were found to be free of necrosis, and necrosed seedlings in nurseries were always otherwise healthy.

Necrotic tissue was examined directly and suspensions in sterile water were planted out on nutrient, cornmeal and 1 per cent. Marmite agars. No bacteria were observed in smear preparations and the only bacteria that appeared on the plates were aerobic-spore-forming organisms which were probably contaminants. Three isolates tested for pathogenicity failed to produce the symptoms of necrosis. Histological examination of the necrotic tissue howed a black deposit filling the cells of the pith ; this was possibly an iron-tannin complex.

It was suggested that the " necrosis " was actually a phenomenon of the growth of the clove seedling under nursery conditions and was not pathological. The physiological implications of this hypothesis were not investigated.

Fungi associated with the Sudden-death Disease

A species of *Melanconium* was isolated from a wide range of moribund clove tissue. It produced wilting and leaf-fall in damaged clove seedlings but did not affect healthy seedlings.

A strain of *Trichoderma viride* was isolated from soil closely adhering to the absorbing roots of clove trees ; it showed some antibiotic activity in culture. The presence of this fungus might be expected to complicate pathogenic phenomena in the absorbing roots.

FOREST PATHOLOGY—D. Rudd Jones

Canker disease of cypresses caused by Monochaetia unicornis

A survey of the disease throughout the Kenya plantations has been undertaken and is now almost complete. The disease has proved serious in *Cupressus macrocarpa* over a wide range of sites but only reaches epidemic level in *C. lusitanica* in the high rainfall areas, especially where ground mists persist at certain times of the year. Such sites are confined to the East of the Rift Valley where the rain periods are April-June and November-December. The badly affected planting areas all have a rainfall of over fifty inches.

Infection occurs most commonly at branch crotches (Nattrass and Ciccarone, *Emp. For. Rev.*, 1947), where there is an accumulation of bark tissue in the form of a " ruffle ". Water running down the stem lodges at these points and provides ideal conditions for spore infection. Wounding is not necessary for infection. From the branch crotch the infection frequently spreads into the stem. Canker lesions are formed and, under favourable conditions, may completely encircle the stem or branch, thus ring-barking it. Spore-producing acervuli erupt through the epidermis of the infected tissue at the extremities of the cankers. The epidemiology has been complicated this year by the long drought and very few actively-sporing cankers have been recorded.

The cambium is normally killed in the line of the lesion but at the sides it becomes very active, forming wound tissue, both bark and

wood, which grows inward, occluding the lesion. Heavy resin production is associated with this reaction.

The disease has been identified in *C. macrocarpa, C. lusitanica, C. benthami, C. arizonica* and *C. sempervirens.* Blocks of trees have been planted to test the resistance of various species to infection. These are of two types :—

(1) Plots of one species only in which every tree will be infected artificially in an attempt to find resistant material within one seed progeny.

(2) Plots of *C. macrocarpa* and a test species in which every tree of the best species will be surrounded by four trees of *C. macrocarpa.* Only the *C. macrocarpa* interplants will be inoculated and the spread of the disease to the test species should yield information on natural infection and field resistance.

The species to be tested are:— *C. macrocarpa, C. lusitanica, C. benthami, C. torulosa, C. torulosa* (Dedza strain), *C. torulosa* (Royi strain), *C. arizonica, Chamaecyparis Lawsoniana,* and *Cryptomeria japonica.*

I am pleased to acknowledge the help afforded to me by Dr. R. M. Nattrass, who placed at my disposal the evidence accumulated since he first recognised this disease.

Armillaria root-rot

This disease affects cypresses, pines, *Grevillea robusta Widdringtonia whytei, Auracaria cunninghamii* and *Accia melanoxylon* in the Kenya plantations. It occurs throughout the Colony but, like canker disease, is only serious in the high rainfall areas.

A number of sample blocks have been kept under observation to determine the rate of spread of the disease in various sites.

The disease spreads almost entirely by root contact, the original source of infection being stumps of trees of the indigenous forest. A list of these trees, in order of their potential danger as sources of Armillaria infection, is being compiled. Fructifications have only been found in two plantations but no doubt occur over a wider area during normal rainfall years. In one plantation stumps had apparently become infected by airborne spores following thinning.

No other serious disease of the softwood plantations has been recorded.

Future Programme

Work during the coming year will be concerned with the completion of the survey of the two main diseases, the continued plotting of sample blocks and the study of the biology and parasitology of the causative fungi. The blocks for testing resistance to canker disease will be infected during the short rains and experiments will be carried out on various methods of control for Armillaria root-rot.

Section of Plant Physiology

STAFF

J. Glover	*Plant Physiologist*
Miss D. M. Cooper	*Scientific Assistant (temporarily from Section of Soil Chemistry).*

Work on the nutrition of maize in sand culture continued throughout the year until I went on leave in October. The methods have been described in the last Annual Report.

The first of the experiments designed to study growth to maturity and the uptake of N. and P throughout the life of the plant was stopped on the 73rd day after emergence of the seedlings above the sand, because of stalk-borer attack. At this stage more than 50% of the plants had "tasseled" and a few which had received the highest level of nutrients, also had well developed "silks". Thus many had reached their maximum height.

As with the young plants, the N P balance was the dominant factor in determining fresh and dry, top and root weights and top/root ratios and the higher the levels at which this balance is maintained (up to the limits of the levels supplied) the bigger the plants. As before too much N relative to P produced visible symptoms of phosphate deficiency though the same amount of P with less N gave normal, healthy plants. Likewise when there was too much P relative to N, nitrogen deficiency symptoms were produced. Of the two, phosphate deficiency was the more serious in that very small plants with dark green narrow leaves patched with purple were produced. When nitrogen was low but phosphate high the plants were much bigger and had pale green medium-broad leaves. Two plants which had this treatment tasseled when but three feet high and only fourteen days after the better nourished plants had tasseled.

The uptake of N and P from the nutrient solutions was obtained by measuring the residual amounts in the displaced solutions every alternate day. Results showed, as might be expected, that the consumption of N increased, as the plants grew larger, up to the limit set by the amount supplied in solution and that the amount consumed was also determined by the N P balance. Thus there was total consumption of N even at the highest levels when the P requirements of the plant were satisfied, but if they were not satisfied then much less nitrogen was taken up from the solution. In cases of extreme unbalance (N proportionately greater than P) much less nitrogen was consumed than by plants receiving the same amount of P but less N.

It was also observed that the medium levels of P permitted the total consumption of the highest level of N though at a date much later than that of the high P series.

The uptake of phosphate also increased as the plants grew. It was also affected by the N P balance, for increasing the concentration of N in the solutions also increased the uptake of P. An apparent high consumption of P by the plants during the earliest stages of growth was traced to the fixing of P by some impurity in the sand so that

early records, until the fixing power of the sand was apparently satisfied, were misleading. Somewhat surprisingly the fixation of P does not appear greatly to affect the growth of the plant, for the final results as shown by weight of tops and roots indicate that the levels of P are effective in modifying growth in proportion to their amounts irrespective of their fixation. It would seem therefore that either the fixation is of a loose nature which the plants may surmount or that the fixing power of the sand is satisfied while the plants are young and make minimal demands on the P supply. P is apparently not fixed to any great extent by contaminating bacteria or algae for it is also fixed in sterile sand and solutions.

The total N content of some 30% of the tops was also measured. The mean percentage by weight of N in them was found to be approximately proportional to the amount supplied in solution. Thus increasing the concentration of nitrate in solution increased the N content of the plant. Further, a calculation of the amount of N consumed by the plants from the solutions was found to exceed that actually found in the plants (the percentage of N in the roots was taken to be similar to that in the tops), by a mean value of less than 7% and of standard error less than 4%. This would appear to indicate that all the nitrate apparently taken up by the plants was indeed actually consumed by them.

Regular checks of the nitrate content of the displaced solutions were made. Over the first fortnight of growth this did not exceed 4 p.p.m. and as the plants grew it rapidly fell to 0.1 p.p.m. and finally became too small to record.

On the basis of this first experiment a second similar experiment was started. It is now at the time of writing 72 days old and some of the plants have tasseled. The uptake of N and P has followed the same course as before and the size of the plants indicates that the weights at harvest may be similar to those of the first. This time, however, the sand was washed for weeks in dilute phosphate solution to attempt to satisfy the fixing power of the sand. When the wet sand was liberating 0.1 p.p.m. of P_2O_5 consistently to many times repeated washings with water, it was then dried and returned to the experimental boxes. Nevertheless it still continued to fix phosphate from the solutions but to such a lesser extent that the effect of the N P balance on the uptake of P was more clearly marked. It is hoped that this experiment can be carried through to maturity.

During my absence Miss D. M. Cooper will be in charge until the second experiment is completed.

Section of Systematic Botany

STAFF

P. J. Greenway	*Botanist*
B. Verdcourt	*Assistant Botanist*

Visitors

The following visited Amani for the purpose of study in the Amani Herbarium:— Dr. J. Gomes Pedro, Junta de Exportaçáo do Algodâo Colonial, Lourenco Marques, Portuguese East Africa, vegetation surveys and the flora of Southern Africa ; A. C. Hoyle, Department of Botany, University of Oxford, the Brachystegias of Eastern Africa ; Dr. R. Germain, I.N.E.A.C., Yangembi, Belgian Congo.

The Herbarium

In the course of the year, 71 accessions of botanical material totalling 2,460 specimens were received for identification. Of these the more important collections were from :—

Uganda :—Agricultural Department (J. W. Purseglove, 189). Forestry Department (Messrs Dale, N.F. Province, Kenya, 59; Dawkins, 63). Dr. G. Salt, Ruwenzori, 19.

Kenya :—Various private collectors, 112 (including Mrs. R. Hornby, 30 ; Dr. G. Salt, Mount Kenya, 12 ; V. G. L. van Someren, 33 ferns, and H. D. van Someren, 37 grasses).

Tanganyika:— Agricultural Department (H. Doggett, 29 grasses). Forest Department (H. Herring, 216). Administration, Government Chemist and Police, 88. Overseas Food Corporation (Messrs. Anderson & Henderson-Begg, 35). Malaria Research Laboratory, Muheza (J. Phipps, 37). E.A.A. & F.R.O. (Messrs. A. C. Hoyle & P. J. Greenway, 86). Dr. G. Salt, Kilimanjaro, 69. Mrs. R. Hornby, Lindi District, 51.

Northern Rhodesia :—E.A.A. & F.R.O. (Messrs. A. C. Hoyle & P. J. Greenway, 28).

Belgian Congo :—Inst. Nat. L'Etude Agric. (Dr. F. L. Hendrickx, 245).

Portuguese East Africa :—Junta de Exportacao do Algodao Colonial, Centro de Investigacao Cientifica Algodaeira (Dr. J. Gomes Pedro, 1,145).

Duplicate material totalling two hundred and nine specimens was distributed to various institutions, over thirty of which consisted of living plants that were sent to the Royal Botanic Gardens, Kew. Further bark material of *Mitragyna rubrostipulata* (K. schum) Havil. has been collected for Professor J. W. Cook, The University, Glasgow, at the request of the Colonial Products Research Council, to enable him to continue his researches on mitraphylline. Owing to the published claim that Cortisone, one of the hormones of the adrenal cortex

giving promising results in the treatment of rheumatoid arthritis, had been discovered in *Strophanthus sarmentosus* A.P. DC., a common West African species, we have been inundated with requests from institutions, mainly American, and private individuals, mostly planters, for seeds and planting material of all the species occurring in Africa. As the only species found in this district *S. courmontii* Sacleaux is rare, we have not been able to meet these requests. In passing I might mention that it has yet to be demonstrated that cortisone is found in *S. sarmentosus,* since the commercial seeds used in the original investigation were not botanically authenticated but were sold under the name *S. hispidus.*

Six hundred and seventy-eight sheets were loaned for study to the following:— Royal Botanic Gardens, Kew, 181 sheets; Botany Department, Natal University, Pietermaritzburg, South Africa, 181 sheets *Fimbristylis* and *Bulbostylis;* New York Botanical Garden, New York, U.S.A., 95 sheets *Strophanthus;* Dr. K. Suessenguth, Botanischen Staatssammlung, Munchen, Germany, 94 sheets, *Achyranthes* and *Aerva;* Dr. Earl E. Sherff, Department of Botany, Chicago Natural History Museum, Chicago, U.S.A., 16 sheets *Bidens* and *Coreopsis;* Prof. C. E. B. Bremekamp, Botanisch Museum, Utrecht, Holland, 7 sheets *Oldenlandia;* Prof. I. L. Wiggins, The Dudley Herbarium, Stanford University, California, U.S.A., 4 sheets *Mimulus gracilis* R. Br.

Determinations at Amani on various plants totalled 4,199. In addition, Mr. Verdcourt worked through the duplicates from Amani that had accumulated at Kew awaiting identification or verification. In the course of this work over 1,800 were named, thus much reducing the number of collections from Amani at Kew awaiting naming. Mr. Verdcourt's work at Kew has been of particular value since it has considerably increased the collection of properly authenticated specimens for study in the Amani Herbarium.

Amongst the more interesting collections named at Amani were: Messrs. Glover and Gilliland's collection of 1,223 specimens from Somalia; A. S. Thomas, 963 from Uganda; J. W. Purseglove, 772 from Uganda, and A. H. B. Child's 194 grasses from the Southern Highlands Province of Tanganyika.

Notes were supplied on East African timber trees, oil plants including essential oils, East African fibre plants, vegetable waxes, the host plants of lac insects, gums, native food plants including vegetables, possible *Eugenia* spp. that might be tried as stocks for the grafting of the clove *Eugenia aromatica* (L.) Baill., weeds of Kenya, bamboos, wild rices in East Africa, galactogogue plants used by Africans in East Africa, medicinal and poisonous plants and the distribution of the species of *Strophanthus* in East Africa.

In the course of the naming of collections, a further 6 type specimens were found in the Herbarium ; and the following new species were described from the Amani Herbarium.

New Species

Agrostis greenwayi C. E. Hubbard (Gramineæ) in Kew Bull. 1949 p. 342, Greenway 6307 ! type.

Capparis victoriæ-nyanzæ Brenan (Capparidaceæ) in Kew Bull. 1949, p. 71, Rounce 307 ! type.

Crepis iringensis Babcock (Compositæ) in The Genus Crepis, vol. 2, p. 341 (1947), Greenway 3543 ! type.

Crepis newii Oliv. & Hiern subsp. *nyasensis* Babcock in The Genus Crepis, vol. 2, p. 374 (1947), Stolz 396 ! type.

Eragrostis emsonii C. E. Hubbard (Gramineæ) in Kew Bull 1949, p. 347, Emson 436 ! type Davies B12 ! Hill 3/30/6 !

Pavetta corethrogyne Bremekamp (Rubiaceæ) in Kew Bull. 1948, p. 350, Zimmermann 1771 ! type.

Pavetta denudata Bremekamp in Kew Bull. 1948, p. 353, Gillman 237 type !

Pavetta fossorum Bremekamp in Kew Bull. 1948, p. 357, Collenette 284; Glover & Gilliland 569 ! types.

Pavetta gillmani Bremekamp in Kew Bull. 1948, p. 351, Gillman 126 ! type.

Pavetta greenwayi Bremekamp in Kew Bull. 1948, p. 354, Greenway 7582 ! type.

Pavetta pammalaka Bremekamp in Kew Bull. 1948, p. 350, Glover & Gilliland 944 ! type.

Pavetta pleiantha Bremekamp var. *glabrifolia* Bremekamp in Kew Bull, 1948, p. 355, Gillman 536a ! type.

Pavetta pleiantha Bremekamp var. *velutina* Bremekamp in Kew Bull. 1948, p. 355, Gillman 536b ! type.

Pavetta somaliensis Bremekamp in Kew Bull. 1948, p. 355, Glover & Gilliland 1160 ! type.

Pavetta spaniotricha Bremekamp in Kew Bull. 1948, p. 352, Davies 889 ! type.

Pavetta tomentella Bremekamp in Kew Bull. 1948, p. 356, Gillman 528 ! type.

Pavetta trichotropsis Bremekamp in Kew Bull. 1948, p. 354, Gardner 611 ! Davies 1166 ! types.

Polystachya acridolens Summerhayes (Orchidaceæ) in Kew Bull. 1947, p. 126, Moreau 492 ! type, 498 !

Polystachya caudata Summerhayes in Kew Bull. 1947, p. 128, Moreau 166 ! type, 782.

Polystachya vaginata Summerhayes in Kew Bull, 1947, p. 130, Moreau 314 ! type, 455 ! 561.

Salvadora persica L. var. *pubescens* Brenan (Salvadoraceæ) in Kew Bull. 1949, p. 90, Greenway 802 ! type.

Smithia platyphylla Brenan (Papilionaceæ) in Kew Bull. 1949, p. 76, Davies 572 ! type, Wigg 49.

Smithia stolonifera Brenan in Kew Bull. 1949, p. 75, Haarer 2089 ! type.

These additional records bring the total number of known isotypes in the Amani Herbarium up to four hundred and seventy-seven.

In the course of the year, 1,257 speciments, of which 167 were grasses, were filed in the Herbarium making a total of 59,557 named sheets. Among these there are 7,593 grass specimens for study.

Field Work

On the 6th June I went to Nairobi to meet Mr. A. C. Hoyle, Department of Botany, Oxford University, and Imperial Forestry Institute, Oxford, one of the members of the Hoyle-Morison Ecological Expedition to East Africa and Northern Rhodesia. From Nairobi we returned to Amani by car collecting *en route*. After a stay of about a week, during which I demonstrated to Mr. Hoyle the local vegetation types and coastal *Brachystegia* north of Tanga on the Tanga-Moa road, we left on a visit to the Forest Department, Tanganyika Territory, at Morogoro. The main object of Mr. Hoyle's visit was to study as many species of *Brachystegia* as could be shown him in the limited time available for covering the great distances involved.

After a few days in the Morogoro District we proceeded with Mr. L. G. T. Wigg, Senior Assistant Conservator of Forests, to Tabora, where in the company of Mr. J. S. Groome, Assistant Conservator of Forests, Tabora, we visited Ichemba and also spent two days on the Ugalla River and Kakoma in the company of Dr. C. H. N. Jackson and Mr. P. E. Glover of the East African Tsetse Trypanosomiasis Research Organisation. On the 29th June, accompanied by Messrs. Wigg and Groome, we went by train to Uvinza, and thence by motor transport to the Mpanda District, Western Province, where we spent a few days studying and collecting the *Brachystegias* occurring there. From Mpanda we travelled east by way of Uruwira, Inyongo to Rungwa River on Itigi-Chunya-Mbeya Road. At Rungwa River I left with Mr. Wigg for Itigi where I met Mr. C. G. T. Morison, Reader in Soil Science, Agricultural Department, Oxford University, and returned with him to Rungwa River. From Rungwa River Messrs. Hoyle, Morison and myself were conducted by Mr. W. Carmichael, Assistant Conservator of Forests, Mbeya, by way of Chunya to Mbeya. From Mbeya I went with Mr. Morison to Tunduma where I left him, he going to Ndola and eventually Lusaka, and I returned to Mbeya. From here I conducted Mr. Hoyle to Masasi and Newala, Southern Province, by way of Njombe, Songea and Tunduru. We returned by the same way, collecting *en route*, as far as Njombe, where we branched off to Sao Hill and thence by the Great North Road to Mbeya-Tunduma-Abercorn, Northern Rhodesia. At Abercorn we were the guests for a few days of Mr. D. Vesey Fitzegerald of the International Red Locust Control Service, who took us to various places of botanical interest in the Abercorn District. From Abercorn I conducted Mr. Hoyle as far as Kasama where I left him to proceed to Lusaka by road, myself returning to Mbeya where I spent a week collecting in the Rungwe District. I then returned to Amani, by way of Iringa, Kilosa and Korogwe, which I reached on the 19th August.

Mr. Hoyle covered a great extent of country in the time available. We traversed the Northern, Tanga, part of the Eastern, Central, Western, Southern Highlands and Southern Provinces. He saw and collected most of the *Brachystegia* that are recorded in

Tanganyika, some sixteen "species". From a general collecting point of view the results were poor, since most of the areas were suffering from a very severe drought and there was little herbage in a fit state to collect. From a visitor's point of view we saw a great deal of country, but from a scientific one too much ground in too short a time was covered to permit critical observations of the vegetation types met with or on the plants we saw.

The thanks of Mr. Hoyle and myself are due to officers of the Forest Department, Tanganyika, and to Mr. D. Vesey Fitzgerald of the I.R.L.C. Service for help and hospitality.

Publications

"Check-list of the Forest Trees and Shrubs of the British Empire." No. 5 Tanganyika Territory, Part II, compiled by J. P. M. Brenan, M.A., in collaboration with P. J. Greenway, F.L.S., Imperial Forestry Institute, Oxford.

"Vegetable Fibres and Flosses in East Africa", P. J. Greenway, *E.A. Agri. Journ.*, Vol. 15, 1950, p. 146.

Review: "Propagation of Trees, Shrubs and Conifers", P. J. Greenway, *E.A. Agri. Journ.*, Vol. 15, 1950, p. 166.

"A Revision of the Genus *Otiophora* Zucc.". B. Verdcourt, *Journ. Linn. Soc.* (Botany) in the press.

"Miscellaneous Notes on East African Plants", B. Verdcourt, *Kew Bull.* in the press.

"The swelling of mould spores in the presence of certain Hydroxy compounds", B. Verdcourt, *Trans. Myc. Soc.* in the press.

Section of Soil Chemistry

STAFF

H. F. Birch	*Chemist*
I. A. Black	*Chemist*
D. W. Duthie	*Chemist*
Miss A. Alexander	*Scientific Assistant*
Miss D. M. Cooper	*Scientific Assistant*
Miss E. Smith	*Scientific Assistant*

GENERAL—I. A. Black

Throughout the year under review, work has been almost entirely confined to the routine analysis of the soil samples received during 1948 and 1949 from the Fertiliser Experiments Scheme and the Highland Fertilisers Scheme but a number of samples of fertilisers have also been analysed at the request of the latter scheme.

Since his return from leave, Dr. Duthie has been assisting Dr. Keen in administrative duties in Nairobi and Dr. Birch, who returned from leave in September, reports his chemical work on a later page. Misses Cooper and Smith arrived from England on the 22nd January, 1949, and Miss Cooper then joined Miss Alexander in the analysis of soils by chemical methods, while Miss Smith started work on spectrographic methods of analysis. Miss Cooper was seconded to the Plant Physiology Section from 4th September to the end of the year. I undertook the direction of the chemical, as well as the spectrographic, analytical work in February, but it will be convenient to treat these branches of the work in separate sections of this report.

CHEMICAL SOIL ANALYSIS—I. A. Black

On assuming the direction of this work in February, I checked the methods then in use and found them generally satisfactory except for the Bouyoucos hydrometer method for mechanical analysis which gave misleading results, when applied to certain soils, owing to incomplete dispersion. A simplified form of the International pipette method, with sodium hydroxide as dispersing agent, was introduced, which has been found to give satisfactory results. The quinhydrone electrode also yielded unreliable pH figures for many soils on account of potential drift and, in the absence of a glass electrode, colorimetric methods were introduced as being more reliable, and sufficiently accurate for routine use. Various minor changes in routine have been subsequently introduced from time to time, notably in the system of subsampling soils for the various analyses and by the adoption of Markham's nitrogen still for the determination of soil nitrogen on a semi-micro scale which has effected a great economy in material and time.

Miss Alexander has carried out Dr. Birch's routine methods for determining phosphates in soils during his leave and has continued to do so, under Dr. Birch's direction, since his return in September, 1949. This work was held up for some months owing to lack of ammonium fluoride.

Most of the soil samples have been in groups of 3 or 4, representing blocks of the same experiment, and this circumstance has materially reduced the number of duplicate analyses required since analyses of soils within a group were generally very similar and consequently mutually confirmatory. Nitrogen, pH and phosphate were determined in each sample but mechanical analyses and carbon determinations were carried out with composite samples representing all blocks in each of the experiments. The total number of soil analyses completed during 1949 was 3,294 made up as follows : 699 pH determinations, 483 nitrogen determinations, 631 analyses each of acid soluble, adsorbed and adsorbed + acid soluble phosphates, 97 mechanical analyses and 122 carbon determinations. In addition something like 850 duplicate determinations of various kinds have been carried out.

By the end of 1949, the chemical analyses of all the 1949 samples, and all the samples received from the Fertiliser Experiments Scheme during 1949, were completed and pH determinations had been made on all the 1949 soils from the Highland Fertiliser Scheme. It is hoped to finish all phosphate and nitrogen determinations on the 1949 samples

by the beginning of February, 1950, but the work on mechanical analyses and carbon determinations has been unavoidably delayed owing to Miss Cooper's secondment to the Plant Physiology Section.

SPECTROGRAPHIC SOIL ANALYSIS—I. A. Black

As previously stated (Annual Report, 1948, p.21), spectrographic methods were ready for routine application to exchangeable base determinations in soils at the end of 1948. At the beginning of March, after an initial period of training in the methods, Miss Smith commenced the routine analysis on the accumulation of soil samples received from both Fertiliser Schemes during 1948, and the spectrographic analysis of these, together with all samples received in 1949, was completed by Christmas. Exchangeable calcium, magnesium, potassium manganeses and, when present in appropriate amount, sodium were determined spectrographically and, in addition, exchangeable hydrogen has been estimated in all the soil samples by a rapid electrometric method, and volumetric carbon dioxide estimations have been made in samples where the presence of free carbonate was indicated by the absence of exchangeable hydrogen.

The same number of analyses could not have been made by purely chemical methods in the time available without a large analytical staff and it may be of interest to examine the work in more detail in order to emphasise the rapidity of the Lundegardh spectrographic method now in use. Owing to other commitments I could not take over any definite part in the routine but, apart from supervising the work as a whole, I was able to give some assistance with odd jobs such as preparing and checking standard solutions, etc., and by carrying out about 75% of the exchangeable hydrogen determinations. Consequently Miss Smith has done the whole of the routine spectrographic and photometric work while the preparation and chemical treatment of the soil extracts has been carried out by an African assistant. Owing to lack of acetylene for 7 weeks and Miss Smith's absence for four weeks on medical grounds, the spectrograph has been in operation for only 32 weeks during 1949, and in this time 842 soils have been analysed and, in addition, 190 complete duplicate analyses have been carried out. This represents 1,032 determinations of calcium, magnesium, potassium and manganese, 198 determinations of sodium, 1,032 determinations of exchangeable hydrogen and 75 determinations of carbon dioxide, giving a total of some 5,433 determinations of various kinds.

The reproducibility of the results has been examined by comparing duplicate analyses and the following estimates of percentage standard deviations were obtained: Ca $\pm$7.2%, Mn $\pm$8.2%, K $\pm$7.2% and Mg $\pm$9.3%, while the standard deviation of the exchangeable hydrogen determinations was found to be $\pm$0.41 m.e./100 g. soil. The percentage standard deviations for determinations of cations have thus all proved to be less than the estimate of $\pm$ 10% made in my Annual Report for 1948.

Time has not permitted any serious development work on spectrographic methods but a new system of dilutions and standards has been introduced, which has greatly increased the range of soils covered by the standard routine, and a new method of plotting working curves has been found to have many practical advantages.

FERTILISER ANALYSES AND MISCELLANEOUS WORK

I. A. Black

During the year under review 22 samples of fertilisers have been received for analysis from the Highland Fertiliser Scheme, and the following determinations have been carried out, mostly in duplicate :—

Mech. analyses	11
Total P_2O_5	16
Citric soluble P_2O_5	16
Water soluble P_2O_5	16
Water soluble Alkalinity	5
Total nitrogen	4
Total potassium	4
Fluorine	9
	81

In addition complete analyses have been made of two samples of lime. This work has been given priority and has been done by various members of the staff but the long and difficult fluorine analyses were all carried out by Miss Alexander.

The usual miscellaneous work, such as preparing D.D.T. solution for Amani, and paste, and book poison solution, for the Library, has been carried out by the Chemical Division throughout the year.

PHOSPHATE FRACTIONATION—H. F. Birch

During my leave (December, 1948, to September, 1949) Miss Alexander continued with the determinations of acid-soluble, adsorbed and acid soluble plus adsorbed phosphates in soils from the Highland Fertiliser Scheme and the Fertiliser Experiments Scheme. This practice of determining three forms of phosphate was started late in 1948 to determine which form gives the best correlation with crop response to phosphates. It can now be stated that, with wheat and maize at least, the acid-soluble phosphate proved less useful than the adsorbed forms in predicting response to phosphates. The estimation of adsorbed forms has also found application in Dr. Pereira's work on coffee soils in Kenya.

In general, but not always, soils with low amounts of adsorbed phosphate responded to phosphate fertilisation. A lack of response, where one would be expected, may be due either to the fact that the crop is getting sufficient phosphate in a form not shown in the analyses, or to the fact that the applied phosphate is unavailable to the plant as a result of phosphate fixation, drought or other adverse factors. To find out why predictions based on soil analyses are sometimes unsuccessful it will be necessary to supplement soil analyses by plant analyses. A preliminary experiment, to determine approximately the limit of adequacy of phosphate in maize, has been carried out on plants grown as far as possible to maturity at different levels of N, P and K. The maize was grown in sand cultures by the Plant Physiologist. The analyses show that under 0.25% P_2O_5 in the oven dry material is symptomatic of phosphate deficiency. This gives a useful guide for subsequent analyses of plants from the field.

The soils so far received for analysis have been taken from the surface six inches. The sub-surface soil, particularly during dry weather, must also supply phosphate to the crop. The analysis of sub-soils will, where possible, be included in future work to see how the data for these soils correlate with crop response.

PHOSPHATE POTENTIALS—H. F. Birch

In June, 1949, I spent four weeks at Rothamsted Experimental Station to study Dr. Schofield's method for the determination of phosphate potentials. The aim of the method is to measure the "potential" of phosphate in the soils as nearly as possible in its field condition by finding the concentration of phosphate in a dilute salt solution that has established equilibrium with a soil sample. The phosphate potential is the negative logarithm of the product of the activities of the calcium and phosphate ions.

The method has now been applied to thirty-eight East African soils of known field behaviour, eleven under maize and twenty-seven under wheat. With practically all these soils the amount of phosphate in solution was so small that accurate determinations of the phosphate potentials were difficult. Moreover, no significant correlation was found between the potentials of the soils and their crop response to phosphates, though here again failure to get a response, where it might be expected, may be due to such adverse factors as fixation, etc. I am in touch with Dr. Schofield regarding modifications that he may advise from time to time in the analytical procedure and hope to have an opportunity further to assess the value of the method.

REDOX POTENTIALS—H. F. Birch

The degree of oxidation or reduction of a soil can have an important bearing on the crop, particularly on one such as rice which is normally grown under water-logged or semi-water-logged conditions. To obtain some practice in the determination of redox potentials, in view of possible future investigations of the redox potentials of East African soils, a number of mud samples have been collected from the bottom and sides of the shallow lake at Amani. Some of the samples were kept under lake water under anaerobic conditions and others under aerobic conditions. Other muds, without supernatant liquid, were kept in a water-saturated atmosphere to prevent drying out. On standing under water there was little difference in the redox potentials (Eh) of the muds under aerobic and anaerobic conditions, but an appreciable difference in the potentials of the supernatant liquids. The Eh of the muds ranged from — 80 m.v. to 100 m.v., sufficiently low for reduction of nitrates, sulphates and ferric iron complexes. On vigorous aeration of the aerobic samples the Eh of the muds rose to about 400 m.v. but gradually decreased on standing until, after a few days, the original Eh values were restored. The same behaviour was observed after a second vigorous oxidation. The exposed muds also changed very little and appear also to be well buffered against oxidation

Section of Statistics

P. Robinson, *Statistician*

I took up my position as Statistician in Amani on November 8th, 1948. A certain amount of initial difficulties were caused by the scarcity of educated Africans of sufficient standard for computational work, and by the shortage of housing for Asians ; but there are now one Goan and two African assistants, and work is progressing satisfactorily.

My first task was to collect and co-ordinate results of all manurial experiments conducted in the four territories. This necessarily meant, of course, that each individual experiment could not be analysed, but that responses of the crops to various dressings of fertilisers should be dealt with in a rather general manner. The main point of these investigations was to determine the behaviour of Uganda Rock Phosphate in relation to that of Soda Phosphate and Triple Superphosphate. There appeared to be very few older experiments, and tentative conclusions had to be based mainly on the experiments conducted by the Native and Highland Fertiliser Schemes carried out in the 1948 season. The results of this examination of the data were the subject of a paper read at a discussion on fertiliser experiments in East Africa held in Nairobi: a brief summary is given in the *E.A. Agric. Journal,* vol. 15, p. 61.

Besides investigations of this type the work of the section may be divided into two main parts :—

1. Advice on design of experiments.
2. Analysis and interpretation of results.

In designing experiments it is essential to realise the difficulties encountered in the field. To acquaint myself with working conditions in the tropics, and also in an attempt to find information on older manurial experiments, the first few weeks of 1949 were spent on tour. This tour embraced all three territories on the mainland and included visits to the following research stations :—

Kenya: Nairobi, Scott Agricultural Laboratories. Molo, Pyrethrum Station. Eldoret, the headquarters of the Fertiliser Schemes, from which visits were made to various experimental sites in the Eastern Province of Uganda.

Uganda: Kawanda Experiment Station. Serere Experiment Station.

Tanganyika: Lyamungu Coffee Research Station, Ukiriguru Experiment Station, Kilosa.

In addition I was able to visit Kongwa and discuss various problems with the Statistician to the Overseas Food Corporation.

As a result of the visit to Eldoret several experiments were designed for the 1949 season. Also several small propagation experiments were designed for the Coffee Research Station, Lyamungu.

In November, 1949, it was necessary to visit the Department of Agriculture, Dar es Salaam, to discuss various important experiments

on wheat in the Iringa District of Tanganyika. This was followed by a visit to the experimental sites and by discussions with the Agricultural Officer, Iringa, on the practical aspects of the problem.

In most cases design and analysis of experiments cannot be completely separated, for the one necessarily follows the other, and generally the designer has to perform the analysis. The results of the above experiments will be sent to Amani for analysis ; and, in addition, other experiments designed and laid down before my arrival out here have found their way to Amani for analysis. In particular statistical work from the Coffee Research Station is being sent here instead of to Rothamsted Experimental Station, England.

Assistance has been given to the Plant Pathology Section in the analysis of field counts of rosette disease of groundnuts, and in the analysis of experiments on aphis transmission of the disease. Several barley and wheat variety trials, conducted by the Plant Breeding Station, Njoro have been analysed, and an experiment to determine the effect of pyrethrum powder on insect infestation of stored grain has been examined. This last led to the usual negative binomial distribution of insect counts ; and the results of the factorial experiment were analysed by the new methods described by F. J. Anscombe in *Biometrika,* vol. 5, p. 165. Results of certain experiments on the transmission of trypanosomiasis were also examined for workers at the Tinde Station.

It is hoped that the help E.A.A.F.R.O. is now able to offer will lead to an expansion in the use of statistical methods in agricultural experimentation in East Africa, so that more information may be obtained quickly and efficiently. This is especially important here, where agriculture is still young and where there are few experimental records on which to base new methods of cultivation or different dressings of fertilisers.

Fertiliser Scheme, 1949

STAFF

L. R. Doughty	*Officer-in-Charge*
D. W. Gourlay	*Field Experimentalist*
T. Graham	*Field Assistant*
W. J. L. Arthur-Worsop	*Field Assistant*
P. H. Hosegood	*Field Assistant*
T. Brodie	*Field Assistant (from 21/8/49)*
H. F. Birch,	*Chemist*
I. W. M. A. Black	*Chemist*
Mrs. M. H. Doughty	*Part-time Stenographer*
N. I. Patel	*Asian Clerk (from 1/7/49)*

This Report is required too early in the year to enable a full discussion of the results obtained from fertiliser experiments during the past two years. It is, therefore, a progress report of field work, but more comprehensive results will be available later in the year.

Experiments have been carried out on the sites used in 1948, except in cases where those have proved unsatisfactory and where we have been extending the work. Some experiments were manured twice during 1948, i.e. for both the long and the short rains. The short rains crops were all failures, the crops drying off in a fairly early stage of development. Crop residues, if any, were dug into the soil in preparation for the 1949 crop. In the 1949 season, we have, therefore, some experiments that have had three dressings of fertilisers, some two, and some that have been fertilised for the first time.

A total of seventy-nine experiments were planted. Twenty-nine of these were in the Lake Province, Tanganyika Territory, twenty-two in Nyanza, Kenya and nineteen in the Eastern Province of Uganda. Nine experiments were planted in the Tanga Province, the first of a series of experiments in the Coastal belt. Fifty-two experiments were harvested, most of the casualties being due to lack of rain ; a few losses were accidental, e.g., premature harvesting by the plot owners and theft of maize cobs from plots.

Basic fertiliser dressings were the same as those used in 1948. A change was, however, made in the method of application. The phosphatic and potassic fertilisers were "placed" in channels, 3 inches deep, covered, and the crop planted above but not in contact with the fertilisers. Nitrogen was applied to the growing crop in all cases, and was "placed", again about 3 inches deep, as closely as possible to the plants, without causing mechanical damage to the roots when cutting the furrows. Lime was not applied again in the repeated experiments nor was it used in new experiments, as it has now been shown that lack of lime is not, in general, a limiting factor in the areas in which we are working ; a few experiments have shown some indication of response to lime and at these places the investigations are being continued.

Harvesting

For the small grain crops and groundnuts the produce of each plot was harvested and weighed. Then a sample, of four pounds of the heads or pods, was taken from the weighed produce of each plot, for

drying and threshing, in order to determine the proportionate decrease in weight from the harvested heads or pods to the dry grain.

In order to determine a similar reduction figure for maize, it was intended to adopt a different technique in an endeavour to overcome the difficulties experienced last year. To this end it was proposed to take a random sample from the standing crop and then harvest and weigh the remainder. This method worked satisfactorily in the Lake Province, Tanganyika Territory ; but in Nyanza the continuance of rains and incidence of storms laid the crops and ruled out this method of harvesting. In four experiments every fifth (or tenth cob in the case of large plots) was taken as a sample. For the remainder all the cobs from each plot were divided into five heaps and one heap chosen at random as the sample. This latter method was most effective.

Crops grown in the 1949 experiments were Eleusine (Wimbi), Sorghum, Maize, Groundnuts, Sweet potatoes, Bulrush millet and *Cenchrus ciliaris*. Difficulties were experienced with sweet potatoes as we could not get sufficient cuttings of any one variety to plant a complete experiment. The varieties available, all local choice, were therefore mixed and spread over each experiment. There is little doubt that the different varieties introduced a further element of variability into the experiments.

Results

In seven of the experiments with Wimbi there was an early, marked, visible response to phosphate, particularly soda and triple super-phosphate, and four others showed visible responses in lesser degree. In only seven of these, however, was the phosphate effect shown in the yield. On the other hand nitrogen produced a considerable increase in yield on eleven out of the fifteen experiments harvested, in spite of the crops being laid. Soda and triple superphosphate hastened ripening to such an extent that in three experiments a considerable amount of grain on phosphate plots was shed.

Experiments showing marked response to phosphate were all in Northern Nyanza, in the Nzoia basin, and in the south-eastern corner of Uganda. On or near all these sites the murram layer is fairly near the surface and, in fact, outcrops in places. Around the arms of Lake Kioga and in Bugishu, phosphates appear to be ineffective in increasing yield but response to nitrogen is most marked.

Only two sorghum experiments show a marked response to phosphates (soda and super). One of these is in the Nzoia basin and the other an outlying experiment in Central Nyanza. In the Lake Province, Tanganyika, yields were fairly good with no outstanding responses to fertilisers. Covered smut was very widespread and attacked a very high proportion of sorghum heads. Only one sorghum experiment was harvested on the Coast and this experiment, in spite of the poor yield due to prolonged drought, showed a response to both super and soda phosphate.

The quick maturing maize, Katumbili, was used in all experiments in the Lake Province, Tanganyika Territory, and all but one of these was on Ukerewe Island. There was no response to phosphates but marked increases in yield from application of kraal manure or nitrogen. In North Nyanza, in the Nzoia basin, there was again a marked response to phosphate (soda and triple super) and also, in

general, to nitrogen. The occurrence of a murram layer at no great depth was also noted on the site where maize has shown response to phosphate. On one experiment in North Nyanza plots were split and half plots composted, at a rate of five tons per acre with the township waste made into compost by the Agricultural Officer, Mr. F. B. Wilson. The overall effect of the compost was not significant although producing a mean increase of over 400 lb. of grain per acre. Sulphate of ammonia gave a significant increase of double this quantity.

Four experiments with groundnuts, in Uganda, showed no response to phosphate, and one experiment only showed a small but significant increase in yield attributable to nitrogen. Four experiments with sweet potatoes in the same area also showed no response to phosphate. Responses to nitrogen were all negative, only one, however, reaching the limits required for significance.

Panicum Miliare was planted at Ukiriguru in a last attempt to get some crop off the experimental area. Originally planted with bullrush millet in November, 1948, and replanted with millet in December and February, it was finally planted with *Panicum* in April, 1949, in the holes in which the millet had been planted and failed to grow. The only interest of these experiments is the high proportionate response to nitrogen and super-phosphate, despite the lapse of time between fertilising and planting the final crop. The yields, however, showed very great variation, e.g. on the four experiments, yields per acre varied from 10 ozs. to about 2,200 ozs., so that these results are of no practical interest.

Discussion, Tentative Conclusions and Future Projects

The outstanding feature of this season's experiments is the widespread response to nitrogen and the comparatively limited areas in which experiments have shown response to phosphates. Broadly speaking, the main phosphate responses in North Nyanza have been obtained in the area marked on Milne's soil map as non-laterised red soils on granite or basement complex rocks. From observations on last season's experiments, it was thought that there would be a response on the red, kikungu soils in the semi-arid area of the Lake Province, but this idea is not borne out by the few experiments that were successfully concluded in this area. Lack of rain may, however, be a contributory factor in this lack of response.

The part of the North Nyanza in which these phosphate responses are recorded, lying north and south to the Nzoia River in its lower reaches, is the eastern offshoot of the Uasin Gishu and Trans Nzoia plateau, where the Highland fertiliser scheme has found widespread responses to phosphatic fertilisers on maize and wheat. Earlier in this report it is noted that in most places where there is a recorded response to phosphate, the murram cap has been noticed at or not far below the surface, but it must be acknowledged that this region has been inspected much more critically up-to-date than the regions of marginal or no response, and that further investigation is necessary.

In the area covered by our experiments once again there seems to be little or no difference in the response to the two types of phosphates, soda and triple super, which is not in full agreement with findings of the Highland Fertiliser Scheme. There may, however, be different interactions between nitrogen and the different types.

Rock phosphate (Uganda), reported as having little effect in 1948, appears to have had some influence on development. Although this does not show as a significant response in yield, wimbi plants that have had two or three applications have shown definitely better growth than the plants on the controls during the early stages of development. In addition to the responses to rock phosphate noted above, after several applications there is a certain amount of evidence of residual effects from the other phosphates, but no direct attempt was made to measure this last year. During the coming season this aspect is to receive closer attention.

We now have a large volume of analytical data from Dr. Black and Dr. Birch on the soils of the experimental areas. These require a considerable amount of statistical work in an attempt to find some basic relations between the chemistry of the soils and their reactions in the field. Mr. Gethin Jones of the Kenya Department of Agriculture has carried out some pot cultures with soils supplied from our experimental sites in Nyanza and his results relating to phosphate responses are in close agreement with the findings in the field.

Regarding the economies of fertilising in the areas where a response is shown, it appears from our results that there is little difference between the single and double rates. It is, therefore, probable that our dressings are in most cases above the economic limit and that we should investigate the effects of lower rates of application of the phosphates. Another factor which we have not yet taken into account is the comparative value of the single super, with a high calcium sulphate content, and the triple super. In Nigeria it has been found that single super is more effective for the same phosphate content than the triple when used on sorghum and groundnuts in the Northern Province. The causes of the differential behaviour are not yet clear. In this connection it should also be noted that Mr. Peat of the Empire Cotton Growing Corporation has recorded at Ukiriguru, Tanganyika, during the past season a marked increase in yield from cotton receiving a dressing of about 300 lb. per acre of single super-phosphate, whereas earlier trials with soda and triple super-phosphate have not given any remarkable results on the hill sand soils.

During this coming season it is planned (a) to extend the work around the areas showing a response to phosphates with a view to defining the limits of the most important areas ; (b) to investigate the residual effects of the fairly large dressings that have now been applied on some sites ; (c) to continue the investigations on the red soils in the semi-arid area in the Lake Province ; and (d) to help as far as physically possible with the investigations being carried out by the Departments of Agriculture in East African Territories.

Acknowledgments

Once more it is a great pleasure to acknowledge with thanks the loyal support and hard work of the members of the fertiliser team and the helpful co-operation received from members of the Administration and Agricultural Departments and of the Empire Cotton Growing Corporation in the districts of Kenya, Uganda and Tanganyika in which we have been active, and to the specialists of the Departments for their helpful interest in the work.

Clove Research Scheme, Zanzibar

STAFF

(1) F. J. Nutman	*Director*
(1) F. M. L. Sheffield	*Specialist Officer*
(2) F. M. Roberts	*Specialist Officer* (arrived 4/12/49)
(1) W. B. May	*Horticulturist*
R. I. Robb	*Scientific Assisant* (resigned 31/12/49)
J. L. Smith	*Scientific Assistant* (arrived 22/1/50)
T. E. C. Robins	*Assistant*

(1) seconded from E.A.A.F.R.O.

(2) seconded from Rothamstead Experimental Station.

During 1949 absence of staff for various reasons has slowed down progress. Dr. Sheffield has been in the U.K. for seven months and Mr. May for five, while Dr. Nutman visited England for a month in connection with the Pemba Control Scheme.

During the year under review, research has been directed towards obtaining evidence on the cause of the Sudden-death disease. The first stage of Dr. Sheffield's anatomical and cytological studies, referred to in last year's report, has been completed and is now in the press. No modifications to the conclusions already reported have been made.

Search for possible insect vectors has continued throughout the year, although the absence of an entomologist considerably handicaps this work. In addition, Mrs. Robb, using Salt's techniques and with the co-operation of the Commonwealth Bureau of Entomology, has studied the insect fauna of typical clove soils. No likely vector has been found, either on the clove tree itself or in the soil. Insect transmission work has therefore been confined to the use of the scale Saissetia. The feeding habits of this insect have been studied by Dr. Sheffield. It feeds exclusively on the phloem in all instars. This is true whether it is cultivated by *Oecophylla longinoda* in the field or moved by hand on to seedlings under laboratory conditions. Extensive series of transmission experiments have now been completed; but no results have emerged as yet.

All preliminary attempts to transmit the disease by mechanical inoculation, either to the clove or to indicator plants, have so far failed. However, these are now being repeated on a more extensive scale, using additional treatments, by Dr. Sheffield and Dr. Roberts.

Mr. May's work on transmission by grafting has continued to be slow because of the difficulties of grafting. Out of 1,420 attempts, only 74 successful unions have been made. Many of these are now planted in the field, but no results have yet emerged. Extension of this work is unfortunately impossible this year because the heavy clove crop has resulted in a lack of grafting material. Furthermore, the drought has made it impossible to select suspect trees with any accuracy.

Grafting to other stocks has continued throughout the year with the dual purpose of testing other *Eugenias* as indicator plants and of finding a more suitable stock for the clove. A total number of 774

grafts has been made, all being seedling approach grafts. The species used as stock were *E. uniflora, E. polyantha, E. jambolana, E. cordata, E. grandis, E. jambosa, E. javanica, E. malaccensis,* and *Psidium guajava.*

The percentage of apparently successful unions is very high indeed but the scion dies shortly after it is severed from its own roots, even though this is done very gradually. The few grafts still surviving are confidently expected to die shortly. It is of interest to note that similar methods using seedling cloves as stock and scion are almost invariably successful. Microscopic examination shews that a true union is formed between clove and clove but not between clove and any other Eugenia so far tested.

Dr. Nutman's physiological studies have now yielded somewhat unexpected results. As previously reported, Sudden-death caused reduction in both assimilation and transpiration, associated with root disorganisation. It has now been shown that the stomatal mechanism is affected at a comparatively early stage of the disease, leaves from suspect trees having significantly smaller stomatal aperture than healthy ones. That this is not the effect of reduced water-uptake is shown by studies of the water-deficit in the tree, suspect trees having a more favourable water-balance than healthy ones. It seems probable that both assimilation and transpiration in the clove are largely controlled by the stomata and thus the observed changes in stomatal aperture seem likely to be the cause of the reduction in assimilation rate and transpiration rate.

This evidence is hard to reconcile with any hypothesis other than a pathogenic one and indicates that, in all probability, the pathogen is either a virus or a toxin-producing fungus. This latter possibility is now being investigated by Dr. Roberts.

Work on the detailed relaionships between climatic factors and water-losses of the clove tree is now being extended, in collaboration with Dr. Pereira of the Kenya Department of Agriculture, to include water-uptake from the soil. This work, when completed, will assist in the interpretation of the field data on the moisture changes of the soil of a clove plantation which have been accumulating over the past year.

The Protectorate Government has now announced its policy for dealing with the Sudden-death disease in the island of Pemba. A Control Campaign is scheduled to begin in July 1950 based on the recommendations of the Keen-Nutman report as modified by the Clove Advisory Mission. The Clove Research Scheme will be intimately associated with this Control project and it is inevitable that, during the coming year, considerable demands on the time of the Research Staff will be made.

Publications

F. J. Nutman and F. M. L. Sheffield, "Studies of the Clove Tree I The Sudden-death disease and its epidemiology". *Ann. App. Biol.* (in press).

F. M. L. Sheffield, "Studies of the Clove Tree II, Histology with special reference to the Sudden-death disease". *Ann. App. Biol.* (in press).

R. I. Robb, "Laboratory trials with some of the newer insecticides against a scale insect Saissetia sp.". *E. A. Agric. Journal* (in press).

Research Scheme on Climatic Data in Relation to Agriculture

A. Walter

I have continued investigations into the effect of radiation diffusivity, with the object of estimating the incoming solar radiation from air-temperature observations alone.

It has been established that the integral of the diurnal temperature curve during sunlight hours (sunrise to sunset) is closely related to the measurements of solar radiation in East Africa, and that on the average the correlation coefficient is above 0.9. The scatter on individual days was then investigated and was found to depend in great measure on the value of T/e, where T is the mean absolute temperature for the daylight hours and e the mean vapour pressure.

This was the first stage of the enquiry; and it has been established that a close approximation to the incoming solar radiation can be obtained as a function of the temperature as derived from the mean of the maximum and minimum readings in a standard screen, the range between the maximum and minimum and the vapour pressure as measured by two readings of the dry and wet bulb.

The next stage is to compare the results with the measurements of soil moisture as determined by Dr. Pereira and to analyse the rainfall records. In order to carry out the latter analysis, 300 East African stations have been coded ready for analysis on the Hollerith machines. The method of analysis to obtain frequencies, totals, etc., is to be discussed with the Hollerith representatives in London while I am on leave next year. The punching and analysis will then be carried out in East Africa by arrangement with the Statistical Department.

The results of this research will be incorporated into the necessary formulae for computing the balance between evaporation and rainfall, or soil moisture and rainfall, whichever proves the most practical; and zonal areas thus demarcated.

Since the trained Asian computer resigned at the end of July, the necessary computations had to be completed by me personally. A considerable saving has thereby been effected on the original grant under the C.D. & W. Acts; and it is hoped that this saving will be made available for completing the application of the results obtained through Hollerith analysis.

Investigations of the Arthropod Fauna of the Soil in East Africa

G. Salt

The principal purpose of the research scheme was to provide exploratory observations on the number and kinds of insects and other arthropods inhabiting East African soil, and on their possible significance in agriculture.

Quantitative studies of the soil fauna were made at the Coffee Research Station, Lyamungu, and at the Agricultural Research Station, Kawanda. Soil samples 4″ in diameter and 6″ deep were examined from various pastures in the neighbourhood of Lyamungu within the altitudinal range of 2,300 to 6,400 feet. They contained a mean population of 306 ± 84 arthropods. That population is only about one quarter of the number found in comparable samples from English pastures. Pasture samples examined at Kawanda were more diverse but, when allowance is made for abnormalities, contained a mean population of 323 ± 27 arthropods. Samples from coffee plots at Lyamungu and from coffee and cassava plots at Kawanda contained more variable and much smaller numbers; the mean population being 253 ± 139 arthropods from samples 4″ in diameter taken to a depth of 12″. All these samples combine to indicate that the arthropod population of East African soils is markedly and consistently lower than that of English soils. This unexpected result may well have significant connection with poor aeration and with other physical and chemical characteristics of tropical soils.

Observations on particular kinds of arthropods present in East African soils were based both upon the samples described above and also upon visual examination during tours of experimental stations and farms. Wireworms were found in moderate numbers at Kawanda, and in heavy infestation at Machame, near Lyamungu. White grubs, cutworms, thrips, soil aphids, coccids and ticks were other arthropods of known economic importance found in the soil samples. None of these were in epidemic numbers. Observations were made on sisal weevil, sugar-cane cockchafers, groundnut pests, the soil fauna of clove plantations, borers in maize and sorghum, and on other insects recognised as pests; but those observations are not amenable to brief summary. On a broad view, two groups of insects stand out as being of general importance in the economy of East African soils: termites and ants. Termites, which are known to be important in the break-down of organic matter, were found in more than half of the samples examined. Ants were not only found in every soil sample studied; they were also the dominant animals present and appear to a considerable extent to control the other fauna.

In order to see how far a knowledge of the soil fauna might contribute to other kinds of work on East African soils, analytical studies of a preliminary nature were made at Kawanda in co-operation with Dr. Griffith in his work on the rejuvenation of soil under elephant grass. The arthropod fauna of soil which had been under elephant grass for different lengths of time was compared with that of similar soil under cultivation and in pastures. Numerically, the fauna under elephant grass was found to be twice as large as that under pasture,

the mean population of the samples being 678 ± 180. Moreover, the composition of this fauna was different from other soil faunas examined in East Africa and, especially in the larger proportion of Collembola, was more like that of temperate grassland. This increase in size and change in composition of the soil fauna under elephant grass may well be connected with aspects of the physics and chemistry of soil, for instance, the development of the crumb structure and the availability of nitrogen.

The arthropod fauna of East African soils is so different from that of temperate regions that a fundamental explanation is called for. The outstanding faunal characteristics are the much smaller number of arthropods in general, the presence of termites, and the overwhelming dominance of ants. These three are doubtless inter-related, and are probably correlated with characteristics of the soil on the one hand and of the vegetation on the other. It cannot be assumed that the role of the fauna is entirely secondary; and it appears that only a co-ordinated physico-chemical and biological study of tropical soil can lead to an understanding of its peculiar properties.

Publications Since 1945

A complete list of the publications from the E.A. Agric. Res. Institute up to the end of 1945 appeared in the *Report for the Years* 1942-1945. The following list brings this list up to date, and includes papers issued since the absorption of E.A.A.R.I. into E.A.A.F.R.O.

Memoirs

88. Moreau, R. E. — Aspects of evolution in the parrot genus *Agapornis*, *Ibis*, v. 90, pp. 206-239, 449-460 (1948).
89. Glover, J. — Environment and the growth of the potato (*Solanum tuberosum*) in Tropical East Africa, *Empire J. Exp. Agric.*, v. 15, pp. 10-26 (1947).
90. Milne, G. — A soil reconnaissance journey through parts of Tanganyika Territory, Dec. 1935-Feb. 1936, *J. Ecol.*, v. 35, pp. 192-265 (1947).
91. Moreau, R. E. — The breeding of the Paradise Flycatcher, *Ibis*, v. 91, pp. 265-279 (1949).

Reprints

34. Hill, A. G. G. — Camphor production in East Africa from *Cinnamonum Camphora*, *E. Afr. Agric. J.*, v. 11, pp. 148-156 (1946).
35. Glover, J. — Some problems of semi-arid areas, *E. Afr. Agric. J.*, v. 11, pp. 133-138 (1946).
36. Moreau, R. E., G. H. E. Hopkins & R. W. Hayman — The type-localities of some African mammals, *Proc. Zool. Soc.*, v. 115, pp. 387-447 (1945-46).
37. Hill, A. G. G. — Selection and improvement of food plants in relation to better nutrition, *E. Afr. Agric. J.*, v. 12, pp. 125-127 (1946).
38. Moreau, R. E. — On writing for this journal, *E. Afr. Agric. J.*, v. 12, pp. 171-175 (1947).
39. Nichols, R. F. W. — Breeding cassava for virus resistance, *E. Afr. Agric. J.*, v. 12, pp. 184-194 (1947).

40. Hill, A. G. G. — Oil plants in East Africa, 1: Groundnuts, 2: Sesame, and 3: Sunflowers, *E. Afr. Agric. J.*, v. 12, pp. 140-152 (1947).
41. Hill, A. G. G. — A note on *Allanblackia Stuhlmanni* Engl., *E. Afr. Agric. J.*, v. 12, pp. 210-211 (1947).
42. Fernie, L. M. — The vegetative propogation of cinchona by cuttings, *E. Afr. Agric. J.*, v. 12, pp. 228-236 (1947).
43. Greenway, P. J. — A veterinary glossary of some tribal languages of Tanganyika Territory, *E. Afr. Agric. J.*, v. 12, pp. 237-244 (1947).
44. Greenway, P. J. & W. D. Raymond — Yeheb, *E. Afr. Agric. J.*, v. 12, pp. 216-219 (1947).
45. Greenway, P. J. — Mahogany in East Africa, 1: The Khayas, *E. Afr. Agric. J.*, v. 13, pp. 8-14 (1947).
46. Kirkpatrick, T. W. — Notes on a species of epipyropidae (Lepidoptera) parasitic on *Metaphœna* species (Hemiptera Fulgoridæ) at Amani, Tanganyika, *Proc. Roy. Ent. Soc.* London, v. 22, pp. 61-64 (1947).
47. Greenway, P. J. — Khat, *E. Afr. Agric. J.*, v. 13, pp. 98-102 (1947).
48. Glover, J. — Water demands by maize and sorghum, *E. Afr. Agric. J.*, v. 13, p. 171 (1948).
49. Moreau, R. E., A. L. Wilk & W. Rowan — The moult and gonad cycles of three species of birds at five degrees South of the Equator, *Proc. Zool. Soc.*, v. 117, pp. 345-364 (1947).
50. Greenway, P. J. — The paw-paw or papaya, *E. Afr.. Agric. J.*, v. 13, pp. 228-233 (1948).
51. Moreau, R. E. — Relations between number in brood, feeding-rate and nesting period in nine species of birds in Tanganyika Territory, *J. Animal Ecol.*, v. 16, pp. 205-209 (1947).
52. Moreau, R. E. — Some recent terms and tendencies in bird taxonomy, *Ibis*, v. 90, pp. 102-111 (1948).
54. Birch, H. F. — Soil phosphates — a review of the literature, *E. Afr. Agric. J.*, v. 14, pp. 29-32 (1948).
55. Duthie, D. W. & L. R. Doughty — Soil fertility in relation to soil conservation, *Communication* 104, *Comptes rendus de la Semaine agricole de Yangambi* (1947).
56. Birch, H. F. & L. R. Doughty — The distribution and interrelationships of the alkaloids in the bark of *Cinchona Ledgeriana*, *Biochem. J.*, v. 43, pp. 38-44 (1948).
58. Fernie, L. M. — The Amani plantations, *E. Afr. Agric. J.*, v. 14, pp. 86-93 (1948).
59. Moreau, R. E. — Ecological isolation in tropical avi-fauna, *J. Anim. Ecol.*, v. 17, pp. 113-126 (1948).
60. Greenway, P. J. — Vegetable fibres and flosses in East Africa, *E. Afr. Agric. J.*, v. 15, p. 146 (1950).
61. Nichols, R. F. W. — The Brown Streak Disease of cassava, *E. Afr. Agric. J.*, v. 15, pp. 154-160 (1950).
62. Keen, B. A. — The Guessers and the Accumulators. Presidential address. *Proc. Nairobi Sci. and Phil. Soc.*, 1949, v. 3, pp. 22-28.
63. Keen, B. A. — The effect of mechanical cultivation on soil degradation. *Bull. Agric. du Congo Belge*, v. 40, pp. 2003-2009 (1949).
64. Keen, B. A. — Economic and social aspects of co-operative and collective farming systems, *Bull Agric. du Congo Belge*, v. 40, pp. 2451-2455 (1949).